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Comparative study of plume axial temperature simulation and full size experiment results

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Abstract

We studied fire plume properties of full-size pool fire experiment under different fire power by using numerical simulation method. Comparing the results with the experiment data and predictions of two classical forecasting models,we discussed the accuracy and reliability of the flume simulation data of the two simulation software. We found that the accuracy of two simulation software was good when stimulating pool fire and the trends of temperature variation was consistent with the experimental data, and temperature predictions of SIMTEC were much closer to real results than that of FDS.

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Keywords: numerical simulation, fire plume, axial temperature, full-size pool fire experiment

Nomenclature

Q	heat release rate (kW)
ΔH_c	heat of combustibles (kJ/kg)
m	mass loss rate (kg/s)
Z*	plume length (m)
δ	the length of divided grid
Subscripts	
x	direction of x axis
y	direction of y axis
z	direction of z axis

1. Introduction

Fire flume is the initial basic form of fire, which can be divided into three obvious area: continuous flame zone, intermittent flame zone and buoyant plume zone. Axial temperature of fire plume is an important characteristic parameter of the fire plume. The highest temperature of the plume occurs in the plume axis and gradually decreases towards the edge of the plume, which is similar to the distribution of speed. The axial temperature changes with the height. In the continuous flame zone, the axial temperature is nearly constant and represent the average temperature of the flame. At the top of the flame, as more and more cold air involved the plume, its temperature drastically decreases. The axial temperature of fire plume is of great importance for automatic alarm system design and fire protection of constructional elements. Based on a

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pool fire experiment which simulates the development of pool fire of large space, having compared the simulation results, experiment data and theoretical prediction data and discussed the accuracy of the numerical simulation and theoretical models on fire plume axial temperature rise of 500kw - 1000kw power in closed space.

2. Experiment and numerical simulation

2.1. Experimental design

The experiment of closed-space plume axial temperature rise is conducted in a one-layer steer structure plant which is 60.00 meters long from east to west, 30.00 meters wide from south to north, 9.2 meters high, covering 1800.00 square meters. Inside the plant, the temperature is 284 K and the pressure is one atmosphere. The elevation and plan of the plant is demonstrated in Fig 1 and Fig 2.

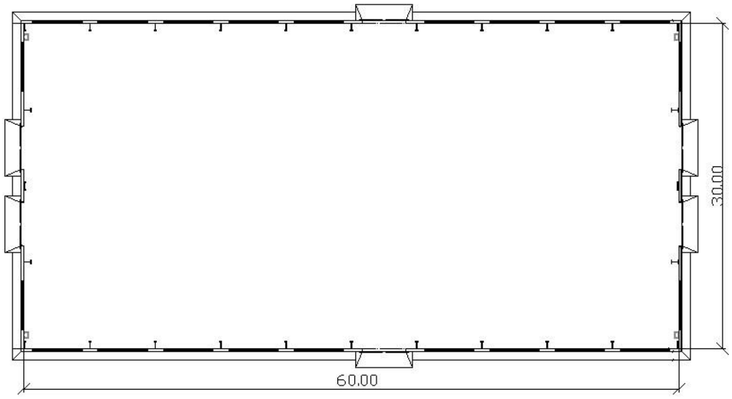

Fig 1. The elevation of the plant

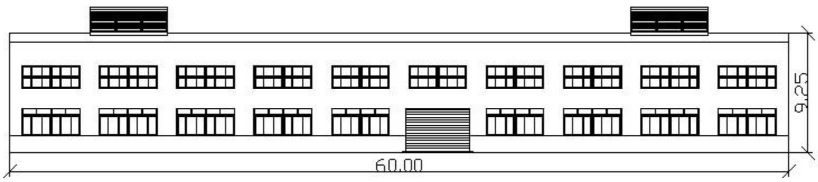

Fig 2 The plan of the plant

The experimental device of plume axial temperature rise is showed in Fig 5. It mainly consists of K-type thermocouple, CELTRON STCS mass sensors and data collector. Diesel is used as the fuel of the pool fire experiment. The calorific value is 42 600 kJ/kg and the combustion efficiency is 93.9%. Two different heat release rate experiments are conducted. The fire source of experiment one is five basins filled with 5 kg diesel each while the fire source of experiment two is eight basins filled with 5kg diesel each. Placed on weighing platform, the basins are connected with mass sensors and data collectors according to Fig 3. K-type thermocouples are set up every 0.5 meters, 4.5 to 7.5 meters above the basins.

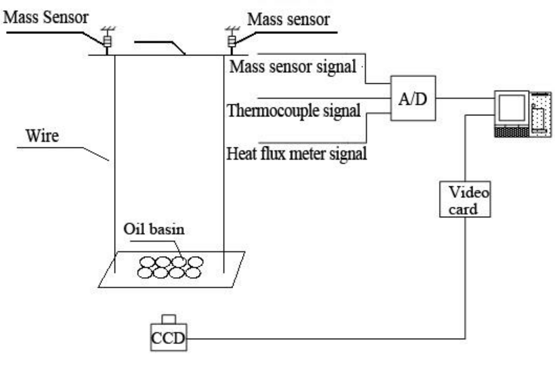

Fig 3 The experimental device of plant fire