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Experimental Study on the Extinguishing Efficiency of Compressed Air Foam Sprinkler System on Oil Pool Fire

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Abstract

In order to evaluate the impact of foam qualities and foam application rates on the extinguishing efficiency of compressed air foam sprinkler system on oil pool fire, a series of large-scale gasoline fire extinguishment experiments have been conducted under different expansion ratios and foam application rates. The consumed foam solution dosages to control and extinguish the pool fire have been calculated out respectively. The result showed that foam qualities significantly affect the extinguishing efficiency and burn back resistance performance of compressed air foam sprinkler system. The optimal expansion ratios of compressed air foam was about 10:1 comprehensive considering the extinguishing performance, re-ignition resistance, burn back protection and economical efficiency. It was found that as the foam application rate increases, the fire extinguishing and burn back protection performances of compressed air foam can be evidently improved. The most economical and efficient foam application rate on gasoline pool fire was 3.48 L/ (min· m^2), and the minimum foam solution dosage to 90% control and entirely extinguish the fire were 0.99 L/ m^2 and 2.38 L/ m^2 respectively. The research results are vital to the engineering application of compressed air foam sprinkler system.

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Keywords: compressed air foam sprinkler system, extinguishing efficiency, pool fire, foam application rate, extinguishing mechanism

Nomenclature

C	foam application rates (L/(min·m^2))
Q	foam solution dosages per unit area
T_c	90% fire control time (s)
Q_c	consumed foam solution dosages per unit area from foam application starts to the 90% fire control time (L/m^2)
T_e	extinguishment time (s)
Q_e	consumed foam solution dosages per unit area from foam application starts to the extinguishment time (L/m^2)
X	foam expansion ratio
$T_{0.25}$	25% drainge time(s)

1. Introduction

Aqueous film forming foam concentrate (AFFF) containing fluorosurfactants are particularly efficient at extinguishing oil fires not only due to their ability to form a film over the fuel surface, but also due to their ability to form firefighting foams to prevent contact between the oil and the oxygen in the air [1-5]. They are widely used throughout both industrial and military fields for the suppression of flammable liquid fires. The traditional foam systems using aspirating-type nozzles

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have several potential limitations[3-7]: (1) poor foam quality due to low expansion ratio and the use of contaminated air for foam generation; (2) the energy required to generate the foam comes from the solution flow which reduces the discharge momentum. The traditional foam-water sprinkler system [6-9] produces poor quality foams that almost have not been expanded by air, which remarkably reduces the fire extinguishing efficiency of the system.

Current researches [5,8-10]suggest that compressed air foam (CAF) sprinkler system is a kind of high efficiency fixed foam extinguishing systems, because of the system can significantly improve the fire suppression effectiveness of the fire extinguishing agent on the burning materials for both Class A and Class B fires by producing uniform and more stable bubbles.CAF with different foams expansion ratios and qualities can be generated by adjusting the system parameters and delivered to the target area through fixed piping grid and CAF nozzles. However, until now, there has not been a study based on large-scale fire extinguishment experiments to evaluate the impact of different foam qualities and foam application rates on the extinguishing efficiency of CAF sprinkler system. It is necessary to investigate the extinguishing efficiency of CAF with different foam qualities and foam application rates, and to determine the optimal engineering application parameters.

This paper describes a series of large-scale gasoline pool fire extinguishment experiments designed to evaluate the impact of different foam qualities and foam application rates on the extinguishing efficiency of CAF sprinkler system. Furthermore, the extinguishing efficiencies of different compressed air foams were analyzed based on the test results and compared by calculating out the foam solution dosages during fire controlling and extinguishing. The research results are vital to the engineering application of compressed air foam sprinkler system, and are helpful to formulate codes and standards for the system.

2. Experiment

A steel test pan with the size of 2.16 m×2.16 m for gasoline pool fire experiments had been made, as shown in Figure 1. The thickness of the steel plates was 4.8 mm. The height of the pan was 305 mm with a continuous horizontal lip 38 mm wide projecting outwards on the top edge of all sides.

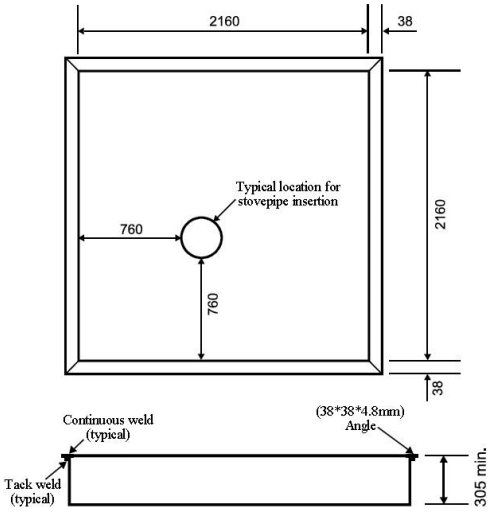

Fig.1. Pool fire test pan

The CAF was uniformly distributed over the target area through the delivery piping grid and CAF nozzles, as shown in Figure 2. Four CAF nozzles were positioned 3 m above the pan at a 3 m by 3 m spacing in a balanced “H” design fed by a supply pipe. The fire test pan was placed under the CAF piping grid. A discharge outlet was installed to control the discharge time of CAF and discharge the residual foam solution. The CAF nozzle was a foam sprinkler for deluge system.