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Analysis of Water Mist Fire Suppression System Applied on Cellulose Fire

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Abstract

Shophouse (Rumah Toko) is a type of building that provides a combined functions for residential and business purposes. Fire risk of shophouse building depends upon the type and volume of the materials stored in the premises. Fire safety improvement for shophouses can be achieved by providing fast response and effective fire supression system such as water mist system. Water mist is a fire supression system that minimizes the risk of material damage by cooling the surface of fuel material. Wood, cellulose material, is one of the most common materials that can be found in shophouse building, thus it is used as fuel material in this experiment. The experimental work was performed in laboratory scale using a single full cone spray with various water pressures of 3, 5 and 7 bar and various fuel placement ((1) center of the room; (2) one corner of the room; (3) all 4 corners of the room). Comparison with numerical simulation using Fire Dynamics Simulator version 6.0 in 1:1 scale with the real test experiment was also performed. Wood crib of 12 cm x 12 cm x 27 cm sizes with an estimated heat release rate of 126 kW/m^2 was applied in this work. The water mist nozzle was placed at 2.5 m height above the floor. The water was supplied by a stand alone pump. The results showed that water mist spray can extinguish the fire effectively under 5 minutes, with 7 bar system pressure as the fastest. Droplet coverage area measured from discharge nozzle, increased in accordance with the increase of water pressure. At higher water pressure, water mist can cover larger fuel surface and perform cooling action, to prevent fuel vapor from reacting with oxygen. Water usage calculated for water mist (NFPA 750) for each system pressure of 3, 5 and 7 bar was 0.15, 0.19, and 0.23 LPM/m^3, respectively. It shows that water mist system requires far less water consumption than the calculated water requirements for sprinkler system (NFPA 13) of 0.79 LPM/m^3 which uses the nozzle's K factor.

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Keywords: water mist, cellulose, full cone spray, cooling surface, water usage

1. Introduction

Water mist system which combines sprinkler system and gas based fire extiguishment agent has been widely used as fire protection in engine room on board ships. It refers to water spray pattern with 99 % of volume in the form of water droplets with less than 1.000 μm in diameters [1]. Water used as extinguishing agent, two times per unit weight as halon 1301 [2], has proven to be very effective. It has been proven that premix flame can be extinguished with approximately 280 g/m^3 room volume with critical flow rate estimated to be less than 2.5 g/m^{2}s. The critical flow rate which is known as CFR is the lowest rate of water application necessary to achieve extinction, but with infinite amount of time available. The mechanism applied in water mist fire protection is performed by gas phase cooling, oxygent placement throughout water vapour, and blocking radiant heat on surrounding fuel surface [2]. In the form of mist, water which has volume of 1 cm^3 can split to droplets of 0.1 mm which is 100 time smaller. This provides contact surface for each droplet to displace oxigen [2]. Based on assumption in the French National Reference Guide concerning the use of manual fire fighting nozzle that not more than 20% of the projected water used, which means 80% on the floor and damaging further properties [2]. Water mist droplets diameter was assumed to function as envelope to its fuel material, preventing damage caused by water used in conventional system.

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In Indonesia, shophouses are very popular since they can be used for both commercial and residential purposes. Nevertheless, a fixed system for fire protection is not usually installed for a 4-storey building or less. Water mist has the potential for wider applications in building fire protection systemas it has less damaging effect on building interiors and goods during fire fighting operation. The system usually worked in high pressure[4] but in this experiment, modest arrangementwas used in low pressure system to perform extinction, which mightreduce the cost so it becomes affordable to wider scope of customers.

2. The object of the study

Full scale experiment was conducted to perform necessary tests in actual room height with controlled parameters. The the experiment was conducted in thermodynamics laboratory with water mist system installed to mimic actual condition of shophouse room and tofurther analyze the requirements needed.Computational simulation was also conducted in order to verify and compare thedata resulting fromfull scale experiment. Extinguishing mechanism correlates between the distribution of water droplets to volume flux spray [1]. Nozzle characterization gives information of water droplet diameter, so it is possible to calculate water usage and the pressure system required to obtain the desired droplet size [1]. It could also provide macro coverage from full spray cone generated by the nozzleto obtain uniform distribution spray pattern and the water flow.

3. Experimental Set Up

3.1. Pre-Test

Wood was utilized as fuel material in this experiment due to its wide usage for household furniture and goods packaging. Stacks of wood in the form of crib which had small dimension of 12 cm x 12 cm x 27 cm was utilized as the fuel in the experiment. The crib consisted of 450 wood sticks, 5 sticks per layer. The heat release rate was 126 kW/m^2, its density was 670 kg/m^3, and the heat of combustion was 1.500 kJ/kg [5]. The pretest in the form of free burn test was performedproduce effective ignition. The result was that the top layer center ignition maintained its form after burning. To accelerate burning, small amount of gasoline fuel was applied on the top layer of the wood crib prior to the test (Fig. 1).

Fig. 1. Wood cribs as source of fuels in this experimental work.

3.2. Experimental set-up

Full scale experiment apparatus was set up by using a steel frame of which dimension was 2 m x 2 m x 2,5 m [6] indoor. Water mist system was developed with pump arrangement to perform extinction of wood crib fire placed in various positions under the discharge nozzle. Characterization ofreprocating pump was set to analyze its compability with the water mist system. The resultswere used to support nozzle discharge in various low pressures : 3, 5, and 7 bars. The nozzle used in this experiment was low pressure nozzle with full cone spray (SPRAYTECS UPV147, brass, ang. 95^o, working pressure 3 – 7 bars, flow rates 2.7 to 7.2 LPM).

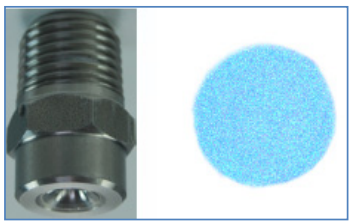

Fig 2. Nozzle