LASHFIRE

Fire Containment on Ro-Ro Ships Using Water Mist and Fabric Curtains

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Studies performed

Experiments

□ Reduced-scale deck

- Pool fire smoke containment with mist
- Black body radiation attenuation with mist

Simulations

- Pool fire tests
- Black body tests

Reduced-scale setup



Reduced-scale setup



Parameters to evaluate

	Option 1	Option 2	Option 3
Barrier type	Water mist curtain	Fabric curtain (full/car height)	No barrier
Flow rate of each nozzle	0.4 lit/min	0.3 lit/min	0.2 lit/min
Fire size	5–30 kW (≈ 17 MW truck fire)	3–8 kW (≈ 4 MW car fire)	
Distance of barriers	2.4 m	2.0 m	0.4 m
Area of windows	15% of side area (open deck*)	5% of side area (closed deck*)	0% of side area (closed deck*)
Fire location	Back wall	Middle	Open side
Rows of barriers	1	2	
Barrier configuration	Series	Straddle	
Obstacles	No obstacles	Series of boxes (≈ trucks)	
Wind	No wind	Parallel co/counter-flow	Cross flow

* Sauter mean diameter

Conducted experiments

#	Fire location	Fuel	Fire size	Area of openings	Barrier	Flow rate of each nozzle	Row of barrier	Distance of barriers	Barrier configuration	Obstacles	Wind
1-1*	Back wall	Diesel	3–6 kW	15%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
1-2*	Back wall	Diesel	3–6 kW	15%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
1-3*	Back wall	Diesel	3–6 kW	15%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
2	Back wall	Diesel	3–6 kW	15%	2 water curtains	0.3 lit/min	Both rows	2 m	Series	No obstacle	No wind
3	Back wall	Diesel	5–8 kW	15%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
4	Back wall	Diesel	3–6 kW	0%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
5	Back wall	Diesel	3–6 kW	0%	2 water curtains	0.3 lit/min	Both rows	2 m	Series	No obstacle	No wind
6	Back wall	Diesel	3–6 kW	0%	No barrier					No obstacle	No wind
7	Back wall	Diesel	5–8 kW	0%	No barrier					No obstacle	No wind
8	Back wall	Diesel	5–8 kW	15%	2 water curtains	0.3 lit/min	Both rows	2 m	Series	No obstacle	No wind
9	Back wall	Diesel	5–8 kW	15%	No barrier					No obstacle	No wind
10	Back wall	Diesel	3–6 kW	15%	No barrier					No obstacle	No wind
11-1*	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
11-2*	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
11-3*	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
12	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 lit/min	2nd			No obstacle	No wind
* Repea	ated test										

Conducted experiments

#	Fire location	Fuel	Fire size	Area of openings	Barrier	flow rate of each nozzle	Row of barrier	Distance of barriers	Barrier configuration	Obstacles	Wind
13	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.4 lit/min	2nd			No obstacle	No wind
14	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.4 lit/min	1st			No obstacle	No wind
15	Back wall	Heptane	5–30 kW	15%	2 water curtains	0.4 lit/min	Both rows	2 m	Series	No obstacle	No wind
16	Back wall	Heptane	5–30 kW	15%	2 water curtains	0.3 lit/min	Both rows	2 m	Series	No obstacle	No wind
17	Back wall	Heptane	5–30 kW	15%	2 water curtains	0.2 lit/min	Both rows	2 m	Series	No obstacle	No wind
18	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.2 lit/min	1st			No obstacle	No wind
19	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.2 lit/min	2nd			No obstacle	No wind
20	Back wall	Heptane	5–30 kW	0%	1 water curtain	0.2 lit/min	2nd			No obstacle	No wind
21	Back wall	Heptane	5–30 kW	0%	2 water curtains	0.2 lit/min	Both rows	2 m	Series	No obstacle	No wind
22	Back wall	Heptane	5–30 kW	0%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
23	Back wall	Heptane	5–30 kW	0%	1 water curtain	0.3 lit/min	2nd			No obstacle	No wind
24	Back wall	Heptane	5–30 kW	0%	2 water curtains	0.3 lit/min	Both rows	2 m	Series	No obstacle	No wind
25	Back wall	Heptane	5–30 kW	0%	1 water curtain	0.4 lit/min	1st			No obstacle	No wind
26	Back wall	Heptane	5–30 kW	0%	1 water curtain	0.4 lit/min	2nd			No obstacle	No wind
27	Back wall	Heptane	5–30 kW	0%	2 water curtains	0.4 lit/min	Both rows	2 m	Series	No obstacle	No wind

















opacity data of diesel fire containment with spray 1 (open windows)





opacity data of diesel fire containment with sprays 1&2 (closed windows)















Upcoming experiments

#	Fire location	Fuel	Fire size	Area of openings	Barrier	Flow rate of each nozzle	Row of barrier	Distance of barriers	Barrier configuration	Obstacles	Wind
1	Back wall	Heptane	5–30 kW	15%	2 water curtains	0.3 lit/min	Both rows	0.4 m	Series	No obstacle	No wind
2	Back wall	Heptane	5–30 kW	15%	2 water curtains	0.4 lit/min	Both rows	0.4 m	Series	No obstacle	No wind
3	Middle	Heptane	5–30 kW	15%	2 water curtains	0.3 lit/min	Both rows	2.4 m	Straddle	No obstacle	No wind
4	Middle	Heptane	5–30 kW	15%	2 water curtains	0.4 lit/min	Both rows	2.4 m	Straddle	No obstacle	No wind
5	Open side	Heptane	5–30 kW	15%	1 water curtain	0.3 lit/min	1st			No obstacle	No wind
6	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 lit/min	1st			Boxes	No wind
7	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.4 lit/min	1st			Boxes	No wind
8	Back wall	Heptane	5–30 kW	15%	2 water curtains	0.3 lit/min	Both rows	0.4 m	Series	Boxes	No wind
9	Back wall	Heptane	5–30 kW	15%	2 water curtains	0.3 lit/min	Both rows	2 m	Series	Boxes	No wind
10	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.4 lit/min	1st			No obstacle	Parallel
11	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 lit/min	1st			No obstacle	Cross
12	Back wall	Heptane	5–30 kW	15%	Fabric curtain (car height)		1st			No obstacle	No wind
13	Back wall	Heptane	5–30 kW	15%	Fabric curtain (full height)		1st			No obstacle	No wind
14	Back wall	Heptane	5–30 kW	0%	Fabric curtain (car height)		1st			No obstacle	No wind
15	Back wall	Heptane	5–30 kW	0%	Fabric curtain (full height)		1st			No obstacle	No wind
16	Back wall		5–30 kW	15%	No barrier					No obstacle	No wind
17	Back wall		5–30 kW	0%	No barrier					No obstacle	No wind
18	Back wall		5–30 kW	0%	No barrier					Boxes	No wind

Black Body Tests





Black Body Tests

before spraying at 4.4 µm wavelength



during spraying at 4.4 µm wavelength





Black body tests





Simulations

Study of spray characteristics based on measurements in the PhD thesis of Sullivan Lechene





Simulations



🗧 FDS 🔺 Sullivan





Numerical campaign

#	Fire location	Fuel	Fire size	Area of openings	Barrier	Flow rate of each nozzle	Row of barrier	Distance of barriers	Barrier configuration	Obstacles	Wind
1	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 l/min	1st			No obstacle	No wind
2	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 l/min	2nd			No obstacle	No wind
3	Back wall	Heptane	5–30 kW	15%	No barrier					No obstacle	No wind
4	Back wall	Heptane	5–30 kW	15%	Wall (full height)		1st			No obstacle	No wind
5	Back wall	Heptane	5–30 kW	15%	Wall (car height)		1st			No obstacle	No wind
6	Back wall	Heptane	5–30 kW	0%	Wall (car height)		1st			No obstacle	No wind
7	Back wall	Heptane	5–30 kW	5%	1 water curtain	0.3 l/min	1st			No obstacle	No wind
8	Back wall	Heptane	5–30 kW	0%	1 water curtain	0.3 l/min	1st			No obstacle	No wind
9	Middle	Heptane	5–30 kW	15%	1 water curtain	0.3 l/min	1st			No obstacle	No wind
10	Open side	Heptane	5–30 kW	15%	1 water curtain	0.3 l/min	1st			No obstacle	No wind
11	Middle	Heptane	5–30 kW	15%	2 water curtains	0.3 l/min	Both rows	2.4 m	Straddle	No obstacle	No wind
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13	Back wall	Heptane	5–30 kW	15%	2 water curtains	0.3 l/min	Both rows	2 m	Series	No obstacle	No wind
14	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.2 l/min	1st			No obstacle	No wind
15	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.4 l/min	1st			No obstacle	No wind
16	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 l/min	1st			No obstacle	No wind
17	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 l/min	1st			Boxes	No wind
18	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 l/min	1st			No obstacle	Parallel
19	Back wall	Heptane	5–30 kW	15%	1 water curtain	0.3 l/min	1st			No obstacle	Cross

Thank You.

Your ideas are highly welcome!



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