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A zone model for fire development in multiple connected compartments

Vladimir Shigunov*

Department of Naval Architecture and Marine Engineering, University of Strathclyde, 48 North Portland Str., Glasgow G1 1XN, UK

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Abstract

Developments in fire engineering and in the understanding of fire influence on humans, together with advances in regulatory base, encourage the use of performance-based methodologies and numerical fire simulation tools in ship design. A numerical method for fire modelling in multiple ship compartments is proposed here, which can be used routinely in the assessment of alternative designs due to its speed and robustness. The method uses an improved treatment of walls between compartments and an efficient algorithm for pressure calculations. The performance of the method is demonstrated on two examples, experimental results for which were available in the literature.

Keywords: Zone model; Multiple compartments

1. Introduction

Fire is one of the main cause of fatalities and damage onboard ships [1]. During design, fire safety is achieved by following the International Convention for the Safety of Life at Sea [2], imposing limitations on the design in terms of subdivision,

*Tel.: +44 141 548 3237; fax: +44 141 548 4784.
E-mail address: vladimir.shigunov@strath.ac.uk.

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Nomenclature

A	area of a surface element, m^2
C	flow coefficient
c_p	specific heat at constant pressure, J/(kg K)
c_v	specific heat at constant volume, J/(kg K)
f	fuel in mass ratios in Section 6
g	acceleration due to gravity, m/s^2
H_c	specific heat of combustion, J/kg
h	enthalpy, J; convective heat transfer coefficient, $W/(m^2 K)$
$\dot{h}$	enthalpy flux, W
k	heat conduction coefficient, W/(m K)
m	mass, kg
$\dot{m}$	mass flux, kg/s
p	pressure, Pa
$\dot{Q}$	heat release rate from fire, W
q	heat flux per unit area, W/m^2
R	gas constant for air, J/(kg K)
S	area of duct cross-section, m^2
S_{side}	area of the side surface of a duct, m^2
T	temperature, K
t	time, s
U	internal energy, J
V	volume, m^3
v	flow velocity, m/s
Y	mass fraction
z	vertical coordinate, m

Greek symbols

α	absorptivity of media
Δt	time step size, s
ε	emissivity of solid surface
ρ	density, kg/m^3
τ	transmissivity of media
τ_w	shear stress on a wall

Indices

b	bottom of a horizontal section of a vent
c	convective; ceiling in Section 7
f	fuel; fire; floor in Section 7
g	gas
i	interface between gas layers