NUMERICAL SIMULATION OF SMOKE MANAGEMENT SYSTEM IN SPRINKLERED CAR PARKS

by

Dalia Essam Eldin Khalil

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
Mechanical Power Engineering

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Title of Thesis:

NUMERICAL SIMULATION OF SMOKE MANAGEMENT SYSTEM IN SPRINKLERED CAR PARKS

Key Words:

Numerical simulation; Fire dynamic simulator; sprinklered car parks; sprinklers operating pressure; visibility levels.

Summary:

The following thesis aims to study the effect of sprinklers activation on the fire induced smoke behaviour and the interaction of water particles with the smoke layer by using Fire Dynamic Simulator (FDS 6.5.3). It was found that the sprinkler activation drastically decreased the visibility at occupant's level. The sprinklers water particles when activated dragged the smoke layer downwards due to its momentum. Increasing the ceiling height to 3.5 m in case of impulse ventilation system and 3.2 m in case of ducted system and the sprinkler operating pressure to a minimum of 4bar may help reduce the problem.

DISCLAIMER

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation	Description
ACH	Air changes per hour
AHJ	Authority Having Jurisdictions
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
CFD	Computational fluid dynamics
CPU	Central processing unit
DNS	Direct Numerical Simulation
EXP	Experimental
FDS	Fire Dynamic Simulator
FFL	Finished Floor Level
Gpm	Gallons per minute
HRR	Heat Release Rate
HVAC	Heating ventilation and air conditioning
IVS	Impulse Ventilation System
LES	Large Eddy Simulation
NFPA	National fire protection agency
SIM	Simulation

Symbol	Description
A	Surface area
$\overrightarrow{A_1}$	Area vector of a cell face
E	Energy
f_b	Body force
ω	spray density
K	light extinction coefficient
T	Temperature
P	Pressure
C	Non-dimensional constant characteristic for every type of object being viewed through the smoke
k	Turbulent kinetic energy
k_c	Thermal conductivity
k_t	Turbulent thermal conductivity
k_{eff}	Effective thermal conductivity
m^o	Mass flow rate
M_t	Turbulent Mach number
N	Newtons
Pr	Molecular Prandtl number
R	Universal gas constant
S_φ	Source term for the scalar quantity φ
S_{ij}	Symmetric rate-of-strain tensor
t	time
U	Time averaged (mean) velocity
u_i	Instantaneous velocity component in the i^{th} direction, m/sec
u'	fluctuating velocity component
V	Volume
$\overline{W}$	Molecular weight of the gas mixture