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FACULTY OF ENGINEERING

NUMERICAL INVESTIGATIONS ON A SMOKE MANAGMENT SYSTEM IN AN ADMINSTRATION BUILDING'S ATRUIM

A Thesis Submitted in Partial Fulfillment of the Requirements of the Degree of Master of Science in Mechanical Engineering

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DEDICATION

To the soul of dear Hussein Ahmed Abdelaal

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Abstract

Smoke is considered the major reason of killing a lot of people in case of the building fire because of the reduction of visibility and asphyxiation fatalities occurred in the smoke event. The present research illustrates a numerical simulation on smoke propagation and smoke control for atrium in an administration building and investigates the effect of exhausting smoke by multi point extraction through rooftop exhaust fans on smoke layer height inside the atrium. ANSYS-FLUENT solver is used to solve two-dimensional Reynolds-averaged Navier-Stokes equations (RANS) combined with K-ε Realizable turbulence model for different study cases in an atrium. Two dimensional rectangular plan that is located at the center of atrium is simulated with the dimensions of 25m width and 20m height using T-squared fire with maximum heat release rate of 5 MW for 180 seconds. All parameters are predicted at vertical levels of 2, 13 and 17 m height from the ground floor. Results show that exhausting the smoke through rooftop exhaust fans maintain the smoke layer at higher level from the ground and has better effect on tenability conditions at human level, increasing make up air inlets levels adversely affect smoke layer height which reduce visibility at human level. Finally, the spacing between extract fans outlet is considered a major factor that should be optimized in order to avoid the plug-holing phenomena.

Keywords: CFD, Atrium, Smoke propagation, Visibility, Heat release.

NOMENCLATURE

Symbol	Quantity
Cp	Constant pressure specific heat , KJ/kg.k
Cg	Solid material specific heat, KJ/kg.k
V	Critical Critical velocity, m/s
Q	Heat Release Rate, Kw
T0	Ambient temperature, oC
D	Diffusion coefficient, Dilution parameter
g	Acceleration of gravity, m/s2
h	Enthalpy; heat transfer coefficient , KJ/kg
hα	Enthalpy of species α , KJ/kg
ΔH	Heat of combustion, KJ/kg
I	Radiation intensity
Ib	Radiation blackbody intensity
In	Radiation intensity integrated over the band n
Ib,n	Radiation intensity of black body integrated over the band n
k	Thermal conductivity; suppression decay factor
K	Light extinction coefficient
Km	Mass extinction coefficient
L	Length scale,m
Q	Total heat release rate, Kw
Q∗	Characteristic fire size, Kw
q	Heat flux vector , Kw/m2
q	Convective flux to a solid surface, Kw/m3
q r	Radiative flux to a solid surface, Kw/m3
R	Universal gas constant, J K−1 mol−1
Re	Reynolds number
S	Unit vector in direction of radiation intensity
S	Visibility , m
Sc	Schmidt number
Sij	Symmetric rate of strain tensor
T	Temperature
t	Time
W	Molecular weight of the gas mixture, Kg/mol
Wα	Molecular weight of gas species α, Kg/mol
X	(x, y, z) Position vector
Xα	Volume fraction of species α
Yα	Mass fraction of species α
ys	Soot yield
Z	Mixture fraction
Zf	Stoichiometric value of the mixture fraction

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