University of Technology, Sydney

Faculty of Engineering and Information Technology

"A numerical investigation of air flow and temperature distribution in a ventilated room"

A Thesis submitted for the Degree of Master of Engineering (Research)

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Certificate of authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Nomenclature

A	area $[m^2]$
Ar	Archimedes number
C	coefficient
CN	contaminant concentration
Cp	specific heat capacity [*J/(kg·K)*]
d	diameter [*m*]
D	draught rating [%]
E	wall roughness
f	the ratio between the covered and exposed surface of a body,
FC	clothing function,
h	heat transfer coefficient $[Wm^{-2}\ /\ °C]$
H	height [m]
k′	is the von-Karman constant
g	is the gravitational acceleration $[m^2/s]$
Gr	Grashof number
L	length scale [*m*]
m	metabolic energy $[Wm^{-2}]$
Nu	Nusslet number
p	pressure $[Pa]$
Re	Reynolds number

Ri Richardson number

Q volumetric flow rate of air [m^3/s]

$\vec{s}$ intermediate parametric function between the computational and physical spaces

t time [s]

T temperature [°C]

u velocity component [m/s]

V velocity [m/s]

v velocity component [m/s]

W free energy production (external work) [Wm^{-2}]

w velocity component [m/s]

$\vec{x}$ grid coordinate [m]

y distance from the neutral plane [m]

Z coordinate [m]

Greek symbols

β incidence angle [$^\circ$]

Γ_t turbulent or eddy diffusivity

δ stretching factor

δ_{ij}	Kronecker delta
ε	turbulent energy dissipation
λ	is the conductivity air [*W/m K*]
κ	kinetic turbulent energy
μ	viscosity [*Pa s*]
ρ	density [kg/m3]
σ_t	Prandtl/Schmidt number
τ	Taylor's jet entrainment constant
υ	is the kinematic viscosity [m^2/s]
Φ	dissipation function
$\vec{\xi}$	computational domain vector

Subscripts

a	air
amb	ambient
b	bulk
bjo	free buoyant jet
cl	the absolute surface of cloths

$_{com}$	combined effect
$_{d}$	discharge
$_{e}$	extracted
$_{fc}$	forced convection
$_{in}$	inside
i	tensor notation $i = 1,2,3$
$_{L}$	local
$_{m}$	mean
$_{n}$	nozzle
$_{nc}$	natural convection
$_{0}$	nominal
$_{oc}$	occupied
$_{out}$	outside
$_{p}$	pressure
$_{ref}$	reference
$_{s}$	supplied
$_{sf}$	stratified
$_{t}$	turbulent
v	vertical direction
$_{w}$	wind

$_{wl}$	walls
$^{+}$	dimensionless
$_{\upsilon}$	viscous
$'$	fluctuations

Abstract

A numerical investigation of ventilation enhancement by a roof-mounted fan has been performed. The commercial code CFD-ACE is used for the quantitative and qualitative analysis of velocity and temperature distributions in a ventilated room.

The parametric study is based on the results of flow and thermal fields obtained from the numerical simulations of three-dimensional models to optimise the location and through flows of a roof-mounted fan to minimise the cooling time of a space once the fan is switched on.

The four ventilator locations have been modelled and the environmental indoor conditions analysed for different speeds of extracted and injected air and temperature of walls. For all cases, Reynolds Average Navier-Stokes, continuity, energy and k-ε equations were defined for steady state and transient, incompressible, turbulent air flows. The second order upwind differential scheme was used and Boussinesq approximation was applied. The equations were solved by using a commercial code based on the finite volume method in a staggered grid system.