ATOA:Public

COMSOL CONFERENCE 2016 BANGALORE

Natural ventilated Building Thermal Simulations

Chaitanya kk, Raj C Thiagarajan

ATOA Scientific Technologies Pvt Ltd

atoa.com

ATOA.com

About ATOA

ATOA is a group of companies with a vision to proliferate engineering for all. ATOA stands for Atom to Application. ATOA currently offers, Multiphysics CAE services, Engineering Apps and 3D printing, through ATOA Scientific Technologies, ATOA Software Technologies and ATOA Smart Technologies, respectively. Our social mission is delivered through our ATOAST Jyothi Foundation.

OUR Purpose

We want to be a Good, Great and Growth Company.

Good: Do Good for our Employees, Client and Humanity.

Great: Develop Great Technology.

Growth:Grow into a Billion Dollar Company by 2020.

Our Solution

Engineering Services, Specialty Multiphysics CAE for Innovation

Engineering Innovation, Online CAE

Engineering Apps for Design on the Go

3D Printing for Next-Gen Products

COMSOL certified consultant

NASSCOM® MEMBER

The 10 Fastest Growing Consulting Companies 2016

CIO Review 20 MOST PROMISING Engineering Design & SERVICES PROVIDERS COMPANIES

Consultants Review 25 Most Promising Project Management & Engineering Consultants 2015

Natural ventilated Building Thermal Simulations

Introduction

- Natural ventilation is the means of air flown into and out of indoor space by natural phenomenon, without the use of mechanical systems
- The design of energy conservation , energy savings buildings based on natural ventilation are gaining significance in this modern world

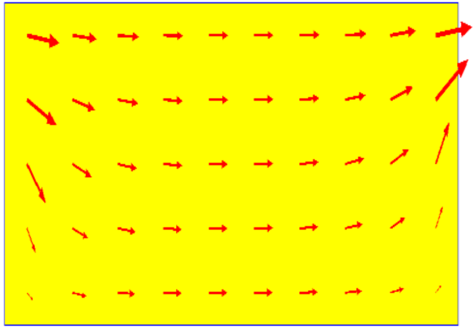


Figure 1. Natural ventilation

Natural Ventilation

- –Natural ventilation will ensure better healthy and comfortable conditions for occupants in living space, along with energy saving
- –In this , focus is to evaluate the difference in performances between natural and forced ventilation and thereby illustrate the potential energy savings by eliminating the usage of mechanical forced systems

Presentation outline

- Mechanisms of natural ventilation
- Governing equations employed
- Design dimensions for simulation
- Simulation results
- Discussion and Conclusions

Mechanisms of Natural Ventilation

1. Wind driven ventilation:

when natural ventilation is driven only by wind, pressure difference is created by wind speed and direction of the wind

$$\Delta P_{wind} = \Delta C_p \cdot \tfrac{1}{2} \cdot \rho \cdot v_{ref}^2 \quad \text{---------} \quad (01)$$

Airflow rate due to wind,

$$Q_V = \pm C_D . A . \sqrt{\frac{2.|(\Delta P_{wind})|}{\rho}} \quad \text{-------} \quad (02)$$

Where,

cP-pressure coefficient, dependent on shape of building,wind direction

P- the pressure difference on the surface relative to the pressure at some reference point.[Pa]

vref- Reference mean velocity of wind, velocity at roof height [m/s]

-Outdoor air density [kg/m3]

QV- Wind-driven ventilation airflow rate, m^3/s

A - cross-sectional area of opening, m^2

CD - Discharge coefficient for opening (typical value is 0,65)

Mechanisms of Natural Ventilation

2. Buoyancy driven ventilation

Buoyancy driven ventilation arise due to difference in temperature.

$$(\Delta p)_{Buoyancy} = \rho \; .g.(H_U - H_L).\frac{(T_i - T_o)}{T_o} \quad \text{--------} \quad (03)$$

Airflow rate due to buoyancy,

$$Q_V = \; \pm C_D.A.\sqrt{\frac{2.|((\Delta p)_{Buoyancy})|}{\rho}} \quad \text{--------} \quad (04)$$

Where,

g - gravitational acceleration, around 9.81 m/s² on Earth

HU-HL- Height from midpoint of lower opening to midpoint of upper opening, m

Ti- Average indoor temperature between the inlet and outlet, K

To- Outdoor temperature, K

QV- Buoyancy-driven ventilation airflow rate, m³/s

A - cross-sectional area of opening, m²

Numerical Simulation

In Simulation, Turbulent flow k-ε model , Heat Transfer and nonisothermal flows are selected.

Flow governing eqn's

$$\rho\frac{\partial u}{\partial t} + \rho(u.\nabla u) = -\nabla p + \mu\nabla^2 u$$ --------> (eqn 01)

$$\mu_T = \rho c_\mu \frac{k^2}{\varepsilon}$$ --------> (eqn 02)

Heat transfer governing eqn's

$$\rho c_p \frac{\partial T}{\partial t} + \rho c_p u.\nabla T + \nabla.q = Q + Q_p + Q_{vd}$$ ------> (eqn 03)

$$q = -k\nabla T$$ -----> (eqn 04)

Design Dimensions

Three cases are considered,

- Case 01: Natural ventilation based simulation
- Case 02: Forced ventilation based simulation
- Case 03: Parametric study on chimney height using natural ventilation, so as to equalize the performance with that of forced ventilation.

Kitchen Dimensions			
	Width [m][	Depth [m]	Height [m]
Kitchen	2.70	2.10	3.30
Cooking floor	2.70	0.60	0.80
Gas stove	0.70	0.43	0.21
Outlet hood	0.89	0.60	0.20
Door	0.10	0.75	2.10

Table 01: Kitchen Dimensions

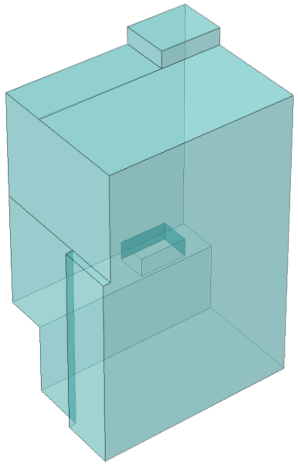


Figure 2. Parametric CAD model

Simulation Results

Case 01: Natural ventilation based simulation

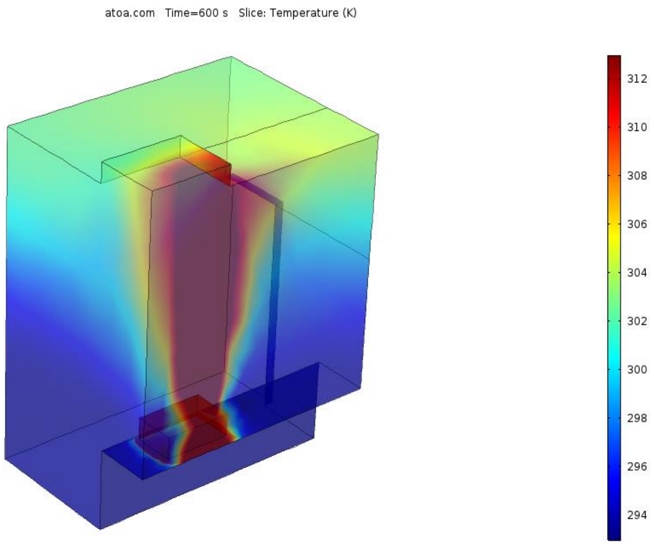


Figure 3. Temperature Profile based on Natural Ventilation

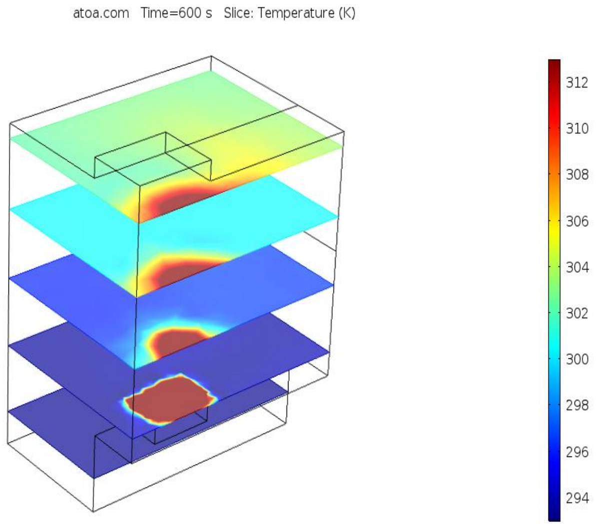


Figure 4. Slice plane Temperature Profile based on Natural Ventilation

Case 02: Forced ventilation based simulation

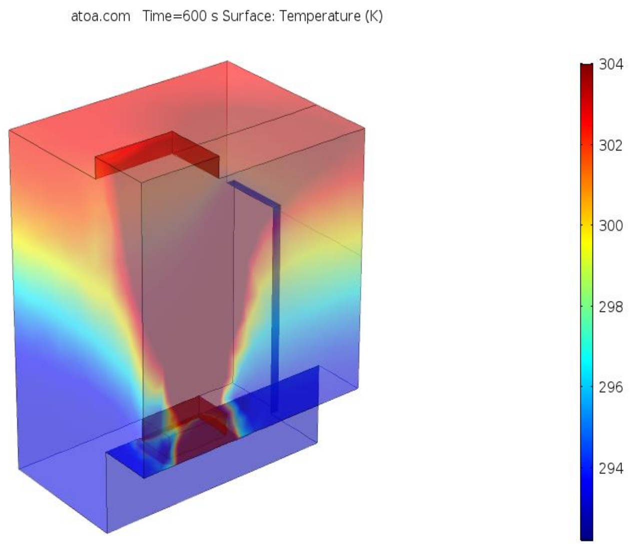


Figure 5. Temperature Profile based on Forced Ventilation

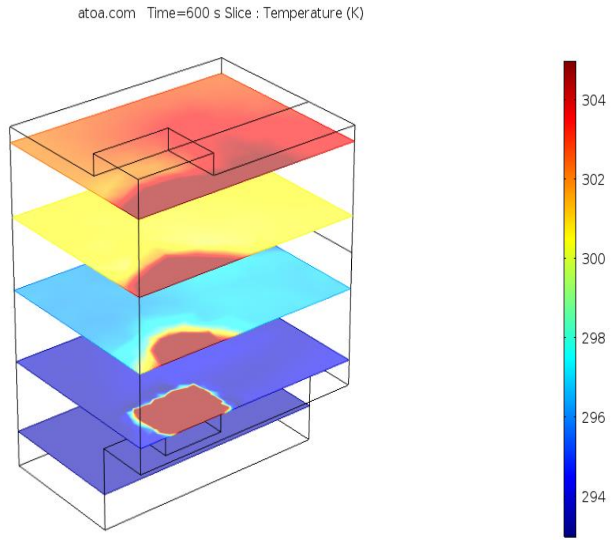


Figure 6. Slice plane Temperature Profile based on Forced Ventilation

Case 03: Parametric study on chimney height using natural ventilation

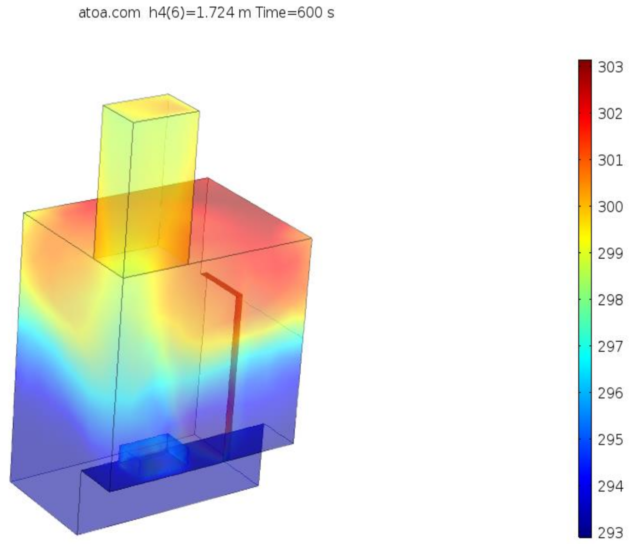


Figure 7. Temperature Profile to replace forced ventilation with increase in chimney heights

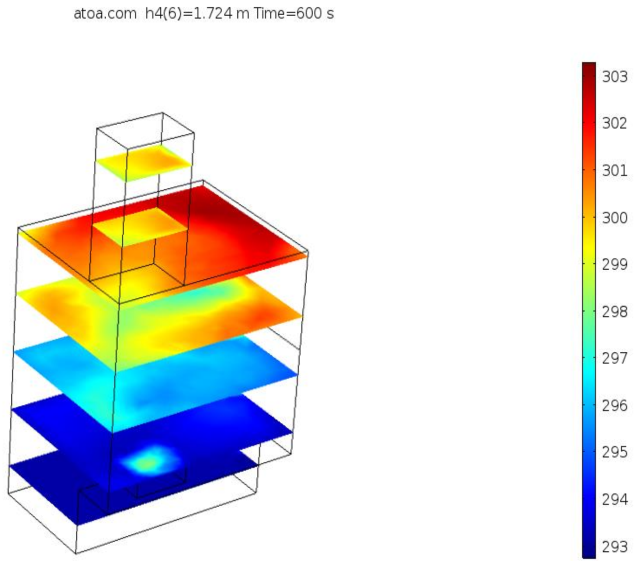


Figure 8. Slice plane Temperature Profile to replace forced ventilation with increase in chimney height

Animation

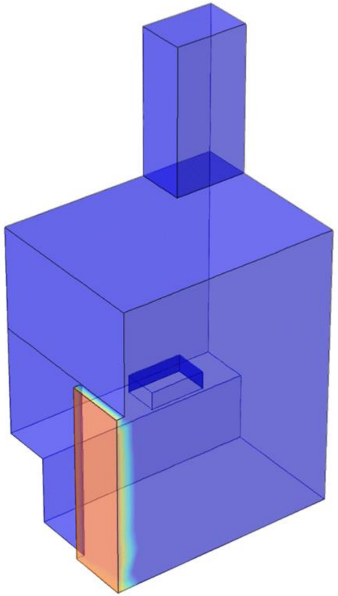
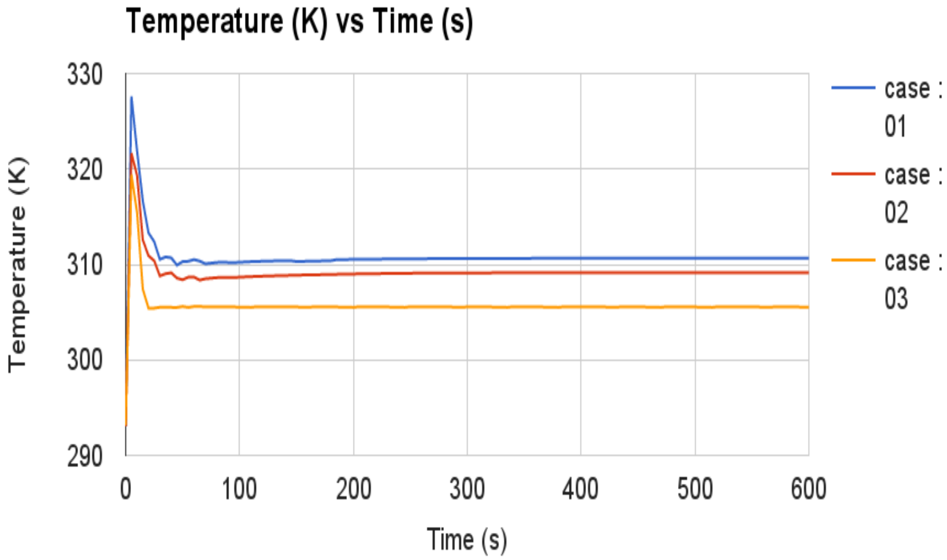


Figure 9: Animation of air flow

Discussion

- Outflow temperatures for natural ventilation are in the range of 293 K -315 K [Fig.3.].
- When an exhaust fan (forced ventilation) is used , temperature ranges between 293 K -304 K [Fig.5].
- Parametric studies on chimney heights were conducted in incremented steps of 0.304799 m (=1 ft) from 0.2 m to 2 m.



➢ At 1.7432 m (=5 ft), the temperature ranges observed between 293 K -303 K [Fig.07].

➢ Comparison of simulation results, shows that, usage of exhaust fan can be replaced by extending the height of chimney further by 1.7432 m (= 5 ft).

Conclusions

- Increase in chimney height has equalized the effect of forced mechanical system, resulting in energy and cost savings

- This cost savings are for small component such as exhaust fan

- If energy and cost savings are considered for entire large buildings, cost savings will be much higher.

Thank You

Visit

atoa.com

write

corp.hq@atoa.com