Thermal Simulations of Naturally Ventilated Buildings

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Abstract

1. Introduction

Natural ventilation is the means of air flown into and out of indoor space by natural phenomenon, without the use of mechanical systems. In view of raising concerns with regard to cost, energy consumption and its effect on environmental impact, the trend of opting for natural ventilation is gaining high significance from all over the world. Natural ventilation will ensure better healthy and comfortable conditions for occupants in living space, along with energy saving. In this paper, a brief review of natural ventilation mechanisms is given. Critical mechanisms are discussed in detail. A model built with COMSOL® software of a representative building component such as a kitchen is considered. The wind driven and buoyancy type ventilation are considered in simulations. The energy saving potential is estimated and highlighted. This study has wider implication on overall natural ventilated building , climate control in automobiles and data center Thermal management.

2. Natural Ventilated Simulations using COMSOL Multiphysics® software

Focus of this work 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. In COMSOL Multiphysics® software, Turbulent flow, Heat Transfer in Fluids and Nonisothermal flows are selected. Three cases are considered, Case 01: Natural ventilation based simulation, Case 02: Forced ventilation based simulation and Case 03: Parametric study on chimney height using natural ventilation, so as to equalize the performance with that of forced ventilation. The boundary conditions, for example, Velocity of air at the inlet is taken as 0.27 m/s and at the outlet opening, pressure boundary condition is applied. Inlet opening temperature of air is considered as 303.15 K. Time-dependent study was performed for performance evaluation.

3. Results and Discussion

Kitchen ventilation simulation study results are shown in figure 1-3. Outflow temperatures for natural ventilation are in the range of 293 K -315 K [Fig.01.]. When an exhaust fan (forced ventilation) is used , temperature ranges between 293 K -304 K [Fig.02]. 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.03]. 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).

4. 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.

Reference

References:
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2. Parrott.et.al, K., J.Emmel and J.Beamish. “Use of kitchen ventilation: Impact on Indoor Air Quality.” The Forum for Family and Consumer Issues 8(1),2003.
3. Chalermwat Tantasavasdi.et.al, Daranee Jareemit, Anake Suwanchaiskul, and Thitiporn Naklada.Journal of Architectural/Planning Research and Studies Volume 5. Issue 1. 2007.

Figures used in the abstract

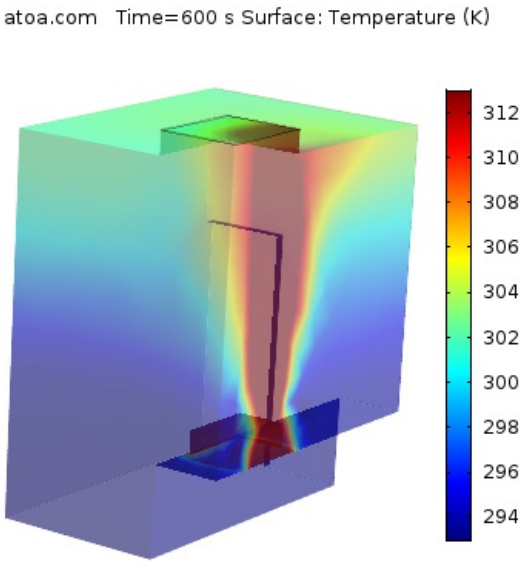

Figure 1: Temperature Profile based on Natural Ventilation.

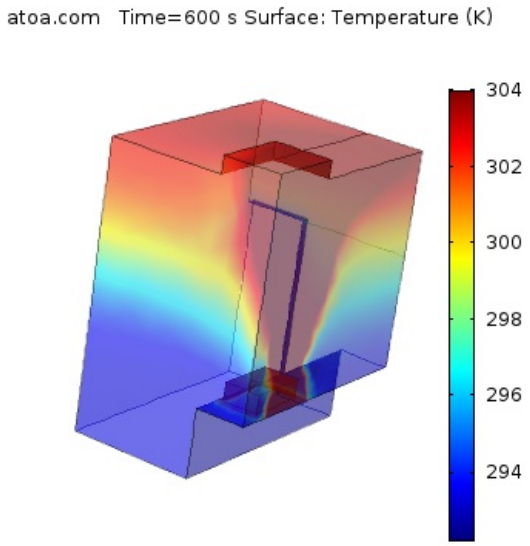

Figure 2: Temperature Profile based on Forced Ventilation.

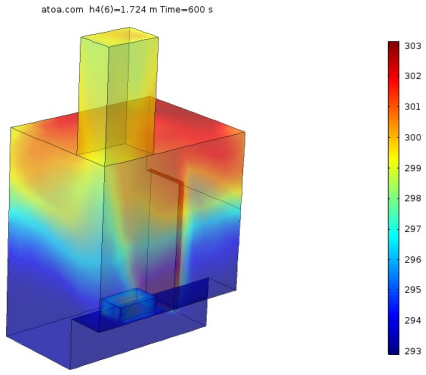

Figure 3: Temperature profile to replace forced ventilation with increase in chimney height.

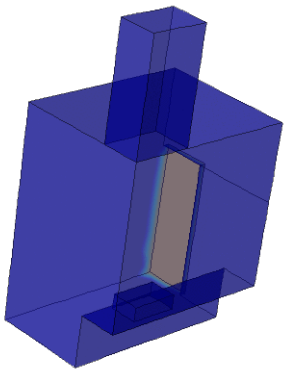

Figure 4: Animation.