# Ventilation Heat Transfer Models in Rooms

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## I. INTRODUCTION

The International Energy Agency forecasts an increase of primary energy demand of 60% by 2030. Meanwhile, fossil-fuel resources are running out, augmenting the energy prices. In addition, the Kyoto protocol binds the governments to reduce the emission of greenhouse gases. Since the building sector accounts for 40% of Europe's energy requirements, the European Parliament ratified the Directive on the Energy Performance of Buildings 2002/91/EC, valid since January 2006. Therefore, to develop low-energy buildings, building simulation is becoming the basic engineering tool in integrated design of buildings and heating, ventilation and air conditioning systems.

The ideal approach to predict the building performance is to solve the conservation equations for the temperature and the velocity fields. However, because of high computational costs of computational fluid dynamics (CFD), multi-zone energy simulation (ES) is currently appraised. A key parameter of building energy analysis is the prediction of interior convective heat transfer (CHT), as identified in a preliminary study [2]. In this work, the effect of the convection algorithm on the night cooling performance in an office room – expressed as weighted excess hours – is compared to the effect of other parameters. As shown in Figure 1, the choice of the convection correlation is of the same importance as the choice of e.g. internal heat gains or sun blind control.

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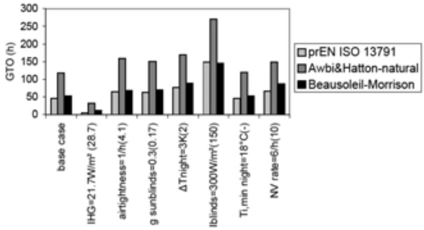


Figure 1 Results of parameter study in ES.

## II. OBJECTIVES

Clearly, more accurate approaches for the range of flow regimes experienced within buildings are required in ES, as is the ability to select an appropriate method for the case at hand and to adapt CHT modeling to changes in the flow. This research aims to develop a better understanding of the important parameters in the performance of ventilation systems – mixing, displacement and cross-ventilation – and to develop simplified ventilation heat transfer models. These models define the relevant characteristics of the airflow pattern, and determine the magnitude of the local CHT between the airflow in its different paths, internal surfaces and internal heat sources. The developed models will be implemented in ES and compared with experimental results.

## III. APPROACH

In this research, dimensional analysis, in conjunction with simple momentum and energy conservation, experiments and numerical simulations will be used.

### A. *Numerical simulations*

As a cost-effective alternative to experimental determination, CFD can provide insight in airflow patterns and the related CHT. However, experience indicates the limitations of the current available CFD-results of typical indoor airflow patterns. Together with the governing equations, the description of the boundary conditions determines to a greater part the reliability and accuracy of CFD-simulations, as identified in the IEA Annex 20-project [1].

### B. *Experimental analysis*

In order to validate the reliability and sensitivity of CFD-modelling, the results will be compared with experimental data. Since convective airflows are highly influenced by the geometry and the dimensions of the space, experiments have to be carried out in full-scale facilities, like the PASSYS cell [3]. In addition, the cells will be used to test the developed ventilation heat transfer models.

## IV. Results

Before investigating different ventilation systems using CFD, the reliability and accuracy of the numerical simulations is tested. Correct modelling of the supply air is regarded most crucial. However, because of the large scale-difference between the diffuser and the room, it is necessary to make an approximation of the supply geometry. Therefore, the sensitivity of the predicted CHT to diffuser modelling was investigated. An inter-model comparison shows a relatively great influence of the diffuser model on the predicted convective heat transfer coefficients (CHTC). The predicted values deviate up to 61% from the experimental results. Additionally, the calculated heat fluxes are compared with results based on empirical CHTC correlations, which confirms the above-mentioned observation, as shown in Figure 2.

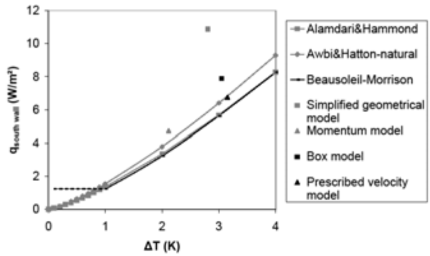


Figure 2 Convective heat flux at wall opposing supply.

Based on the previous study, the applicability of experimentally derived convection correlations for different flow regimes is investigated using CFD. This work demonstrates that the most of the convection algorithms are only valid for particular flow regimes.

## V. Conclusions

This paper presented the importance of CHT in predicting the building performance. To develop simplified heat transfer models, CFD proves to be a cost-effective tool. However, further research on the reliability and accuracy of CFD is necessary, before developing ventilation heat transfer models.

## Acknowledgements

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## References


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