Available online at www.sciencedirect.com
SCIENCE DIRECT
Energy and Buildings 37 (2005) 461–469
ENERGY and BUILDINGS
www.elsevier.com/locate/enbuild

Symbiosis of the double skin façade with the HVAC system

W.J. Stec*, A.H.C. van Paassen

TU Delft, Mechanical Engineering, Mekelweg 2, 2628 CD, Delft, The Netherlands

Received 5 May 2004; received in revised form 18 July 2004; accepted 10 August 2004

Abstract

Impact of the natural ventilation on the building depends on the design of the several components of the building like façade, HVAC and control system. Paper presents several tests of the building with different selection of the components. The double skin façade is compared to the single skin façade with the external or internal shading device and with climate wall. Furthermore, impact of the mechanical or natural night cooling, predictive control is discussed. Final solution represents the possible reduction in HVAC system to balance the costs of the double skin façade. The tests were carried out with the simulation program built in Simulink™ validated with the measurements taken in Test cell at TU Delft as well as in the real office building. Each solution is qualified based on differences in capacities, energy consumptions and costs for various solutions of façade, HVAC system and control. As a final solution optimization of the HVAC system is presented

Keywords: Natural ventilation; Double skin façade; Control; Simulation

1. Introduction

The demand to reduce the energy consumption of the HVAC system is pushing designers into application of new solutions for the ventilation system. There are several ideas that are gaining attention due to their saving energy abilities. Among them there can be distinguished; multiple skin façades, natural ventilation, night cooling, effective use of the ground, solar and wind energy. The extensive research done in these fields succeeded in a number of the fruitful applications.

Research done at TU Delft was primarily pointed at multiple skin facades. Nevertheless, main advantage of the diversity in design of the external façade is the opportunity to apply other energy saving ideas. To select the most appropriate design of the external façade, its function and efficiency of the whole building should be determined carefully. That is why several possible selections of the available components of the building should be tested together in order to optimize each design of the building.

Previous research [5] analyzed impact of different façades on the energy consumption of the building. The best appeared to be traditional façade with the external shading. Compared systems however, were not optimized concerning the integration of DSF and HVAC by control system.

Moreover, there are a lot of simulation programs that can calculate the energy performance of the building. Some of them proofed their reliability [2]. Nevertheless, innovative designs require flexibility in simulation. It is important to have a free access to the simulated phenomena and create one's own components or easily optimize the existing ones. That is why our research concentrated on creating the simulation program with the use of Matlab/Simulink™. Additional advantage of Simulink™ is that it is a sort of platform in which many people from different research groups may produce their own components that can be exchanged and used by other groups without any adjustments. There are already several platforms existing in which different users of Simulink™ may exchange their models [4,8].

Furthermore, there was created a dynamic simulation model of the building together with different façade constructions as well as HVAC system and integrated

* Corresponding author.
E-mail address: w.j.stec@wbmt.tudelft.nl (W.J. Stec)
URL: http://www.ocp.tudelft.nl/et/Research/EnergyInBuiltEnvironment/SecondSkinFacade/DSF/index.htm.

0378-7788/$ – see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.enbuild.2004.08.007

Fig. 1. Scheme of the data flow in the simulation model.

control strategy for all passive and active components of the building. With the use of the simulation model various possible settings of the building could be qualified concerning the energy consumption, capacity of the system and indoor comfort quality.

2. Simulation model

The simulation model of the building with the additional components such as double skin façade, HVAC system and control strategies was implemented in Simulink™. The preprocessing of input weather and building data was done with Matlab. Matlab function extracts from the general weather matrices values of the temperature, solar radiation or wind conditions. Based on this information it calculates the weather inputs referenced to the particular building, like distribution of the wind pressure [1] and solar radiation on each surface of the building. The connection between Matlab and Simulink™ is shown on the Fig. 1.

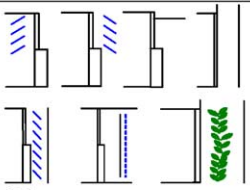
The library of possible components of building is built in Simulink™. Apart from the main body of the building, there are several options for the façade, HVAC system and control strategy. Table 1 shows the exemplary selection for each of the group. Every simulation model with different components was validated with the use of measurements and other simulation programs.

Basically, the library of facades was used to analyze thermal and airflow performance of the external façade. This means that temperature and airflow distribution in the façade was verified for different selections of construction, functions and materials. Afterwards the façade was combined with the other components of the building to determine the total performance of the building. To draw reliable results the simulation needed to be done for the period of a whole year. The possible results were:

1 yearly energy consumption for heating, cooling and ventilating,
2 indoor comfort quality,
3 necessary capacities of the system,
4 monitoring of all possible variables like temperature and airflow distribution in each part of the total system.

The main window in the library is visualized as shown in Fig. 2. By entering each of the groups it is possible to make a

Table 1
Exemplary selection of components of the building inside of Simulink™

Facade	HVAC system	Control strategy
 Others…	• Double duct ventilation • Single duct ventilation • Natural ventilation • Complete air handling unit • Others…	• Passive and active components (hybrid ventilation) • Night cooling • Weather prediction • Day light control • Others…

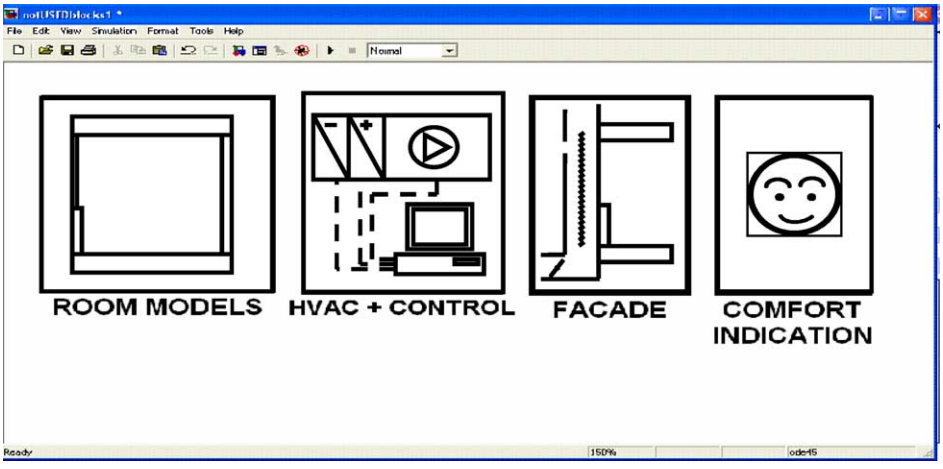


Fig. 2. Library of the components in Simulink™.