Optimization of a Decentralized Ventilation System Integrated into a Window Frame Cavity

Degree programme: Master of Science in Wood Technology
Thesis advisors: Dr. Mohammad Rahiminejad, Prof. Dr. Steffen Franke

Centralized heating, ventilation and air conditioning (HVAC) systems usually require extended ductwork, and individual zoning control is not possible. Decentralized HVAC systems can be installed with limited ductwork and show a higher energy efficiency. This thesis aims to improve and optimise the performance of a novel compact HVAC system accommodated in a window frame structure by using computational fluid dynamic (CFD) simulations.

Introduction

Decentralised ventilation systems generally have shorter ducts than centralised ones, resulting in a higher efficiency. Furthermore, only limited additional ductwork is required, which reduces the constructional costs for a decentralised ventilation system. A novel ventilation system integrated into the window frame structure, which offers a suitable solution for buildings designed for high energy efficiency, is analyzed in this thesis.

Concept

The cavity of the window frame houses two ventilation systems, one per vertical frame element (Figure 1). Each ventilation system includes a fresh air and an exhaust air channel. Both of which contain a filter and a fan. A heat exchanger is installed between the fresh air and exhaust air channels for heat recovery.

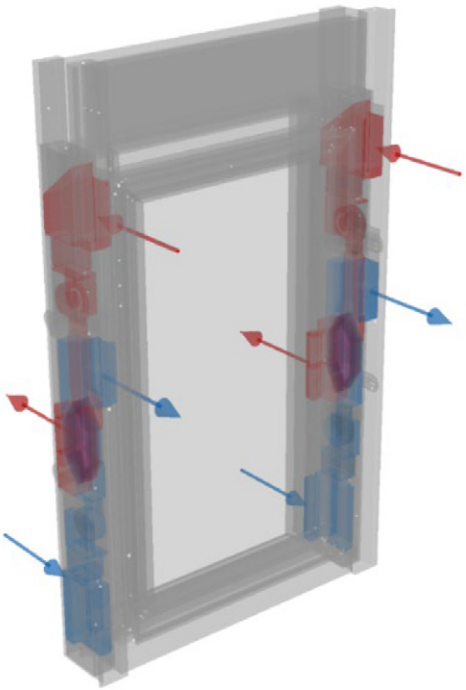

Figure 1: Arrangement of the ventilation system in the cavity of the window frame (blue: fresh air, red: exhaust air)

As illustrated in Figure 2, each ventilation system contains key components, including a filter, fan and heat exchanger. The two ventilation systems intend to supply a minimum fresh air volume flow rate of 30 m^3/h to a single room in residential buildings, as required by the SIA 382/5 standard.

Goals

This thesis is part of a research project at the Bern University of Applied Sciences in collaboration with Wenger Fenster AG as the industry partner. The development and improvement of this novel product includes the following main tasks:
– Optimization of the ducts' geometry (Figure 2) using CFD simulations
– Evaluation of the points of operations for numerous combinations of fan, filter and heat exchanger
– Evaluation of the system performance for numerous combinations of key components

Results

The thesis outcome showed the importance of CFD simulations in optimization processes. Furthermore, continuous improvement of the duct system led to a reduced pressure loss in the system. The points of operation derived for various combinations of key components show that the minimum requirement for the fresh air volume flow rate can be fulfilled.

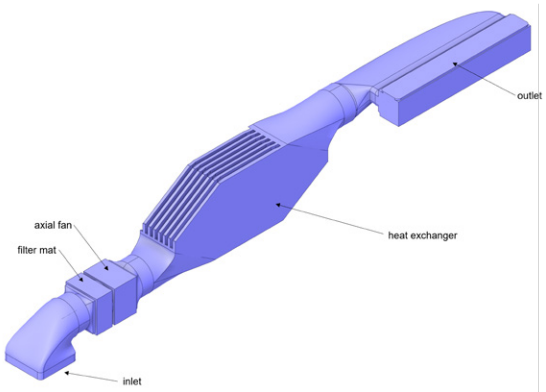

Figure 2: Optimized fresh air channel including a fan, filter, and heat exchanger.

Joel Philippe Karolin
Complex Timber Structures