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HYBRID VENTILATION IN PASSIVE HOUSE IN LATVIA

HIBRĪDVENTILĀCIJA PASĪVAJĀ ĒKĀ LATVIJĀ

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Introduction

The primary function of the ventilation is to provide acceptable indoor air quality and thermal comfort. Good indoor air quality not only improves the working capacity of humans, but also reduces the risk of allergies and respiratory problems.
Hybrid ventilation system is innovative and potential energy-efficient method for ventilation and cooling of the building. The operation of the technology, such as hybrid ventilation, is considered to be a comprehensive strategy that aims to reduce the overall energy consumption in the building, as well as to create healthy and stimulating environment for its inhabitants.
Hybrid ventilation is a combination of two autonomic and nowadays developed ventilation systems. For achieving high performance results, it must combine the best qualities of each system. The high performance of hybrid ventilation is not imaginable without intelligent control system. [1]
The main advantages of hybrid ventilation are wide application possibilities in different types of buildings and in different climate zones, as well as minimised energy consumption comparing to conventional mechanical ventilation systems and the possibility to get good internal environment. The good practice shows that the mechanical ventilation systems are used to provide good internal environment in passive houses. As the hybrid ventilation is a relatively new approach for

ventilation systems, its adaptation in passive house can be promising, because the aim of the passive house is to achieve minimal energy consumption. It must be noted, that this new solution for efficient ventilation of buildings is under research now, and mostly it is practically adapted for office and educational buildings with exploring the performance of ventilation, determining problems and searching for better solutions, as well as comparing the initial costs and operational costs of such buildings. The practical examples of hybrid ventilation application in residential buildings are few. The possible reasons for such situation could be: firstly, the common opinion that hybrid ventilation systems are more likely to be adapted for large planning buildings, secondly, comparatively complicated prediction of ventilation performance and control, thirdly, that the technology is in the research phase.

The aim of the current research is to explore the hybrid ventilation as a subsystem of the passive house, which is adapted for Latvia's climatic conditions, using simulation program – TRNSYS.

TRNSYS is a complete and extensible simulation environment for the transient simulation of systems, including multi-zone buildings. It is used by engineers and researchers around the world to validate new energy concepts and to improve existing ones [2].

Research project

In the framework of the current research several tasks were solved to achieve the research aim – to create a simulation model of hybrid ventilation with the help of TRNSYS and to apply it to the Latvian passive house. Possible solutions and methods were explored for creating a hybrid ventilation system and predicting its performance, which are used around the world.

In the current research the hybrid ventilation was build in the TRNSYS simulation program. In order to adapt hybrid ventilation to the existing model of the Latvian passive house, careful research of the existing model was conducted. The geometry of the Latvian passive house was chosen considering possible location of rooms, maximum usage of daylight, to minimise the total energy consumption in the building. The location and distribution of windows area was predicted for maximum usage of solar energy and providing daylight in the house. The house was planned for one single family (two adults and two children) with total heating space – 160 m^2.

The hybrid ventilation system was created in the Latvian passive house model in the TRNSYS subprogram TRNBuild with the primary attention paid to operation modes of the ventilation system. The hybrid ventilation and its control systems were modelled in the program TRNSYS Simulation Studio.

The hybrid ventilation system in the current research consists of two autonomic subsystems – natural ventilation and mechanical ventilation with heat recovery device. The ventilation system was built as a changeover system, the system operated in mechanical or totally in natural ventilation mode. The control system, which is very important for such a system, was created in the framework of this research.

The locations for air intake and exhaust of the mechanical ventilation system were chosen according to experience from ventilation system implementation in passive houses in Germany and other countries, as well as considering laws and regulations in Latvia [3]. Several conditions were taken into account that were all connected to air circulation inside the house:

- from zones which are less polluted to zones which are more polluted,
- from zones where requirements for air quality is higher to zones were they are not so high,
- from zones which are occupied longer to zones which are not occupied so long.

In Latvian passive house were distributed, that zones with fresh air supply are three bedrooms and living zone, and zones with polluted air exhaust are two bathrooms and kitchen.

The mechanical ventilation system was made of inlet and extract fans, and a cross flow plate heat exchanger for heat recovery from outlet air to inlet fresh air.

In this research the thermal comfort was adjusted with occupancy of the building. When the building was not occupied the indoor air temperature could not be lower than +17°C. When the building was occupied the indoor air temperature could not be lower than +20°C.
There were examined several possible control strategies for successful operation of hybrid ventilation system. That was important to provide that both integrated systems can collaborate and consider outside climate conditions and internal climate, which was defined with indoor air temperature in this research.
During creation of the control system a problem appeared with interconnectedness of the subsystems operation, because the heating system was built in the subprogram TRNBuild in the existent Latvian passive house model and it worked just to provide the definite temperature schedule. For coordinated operation of the ventilation and heating systems, the heating system must be build in the program TRNSYS Simulation Studio, which would allow to adapt the control system and to coordinate its operation with other systems of the building.
The control system created in this research is showed in figure 1.

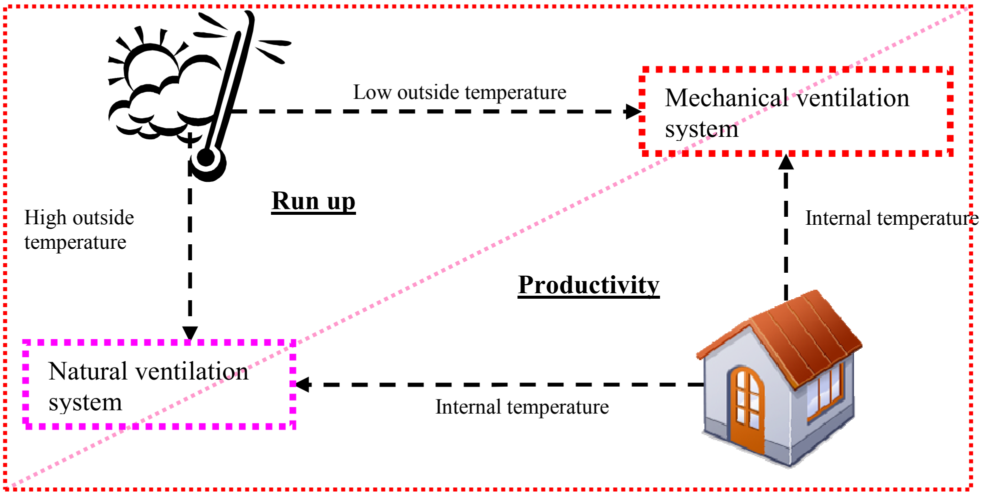

Figure1. Principal control system of ventilation Principiālā ventilācijas vadības shēma

The created control system of ventilation provided that:

- operation mode of both subsystems was depending on outside temperature,
- the productivity of operating system was depending on inside temperature and was definite with air change per hour.

In the current research the definite outside temperature was called as control temperature.
The hybrid ventilation system was characterized with such parameters:

- during the time when the house was occupied and inside air temperature was 20°C, the ventilation rate changes depended on inside temperature and ventilation rate was as from 0,5 air changes per hour. When the indoor air temperature increased, the ventilation rate would grow in such a way to provide an acceptable level of comfort;
- during the time when the house was not occupied, the ventilation rate for the mechanical system would be 0,3 air changes per hour with a view to save the energy and the ventilation rate for natural system would be 0,6 air changes per hour for sufficient comfort level.

The hybrid ventilation was built to avoid use of mechanical air conditioning system. Thus, with an increasing rate of natural ventilation it could be possible to achieve comfort inside the building without increasing energy consumption of the building at the same time.

The characteristics of the hybrid ventilation was described with mathematical equations in the program TRNSYS.
The operation of the system created in the current research was analysed by changing the operating modes, which was defined with outdoor air temperature, and by examining internal temperature and changes of energy consumption for heating, heat loses in ventilation system and operation time of each subsystem. The system operation was inspected at control temperatures 8, 10, 11 and 13 °C. So the natural ventilation would be in operating mode above the control temperature, and the mechanical ventilation would be operated, when the outside temperature would be below defined control temperature.
The results were obtained as the thermal energy gains of solar radiation, heating system, ventilation system etc. in kWh per year and the indoor air temperature graphs with annual temperature distribution in zones. One of the hybrid ventilation model simulations is represented in figure 2.

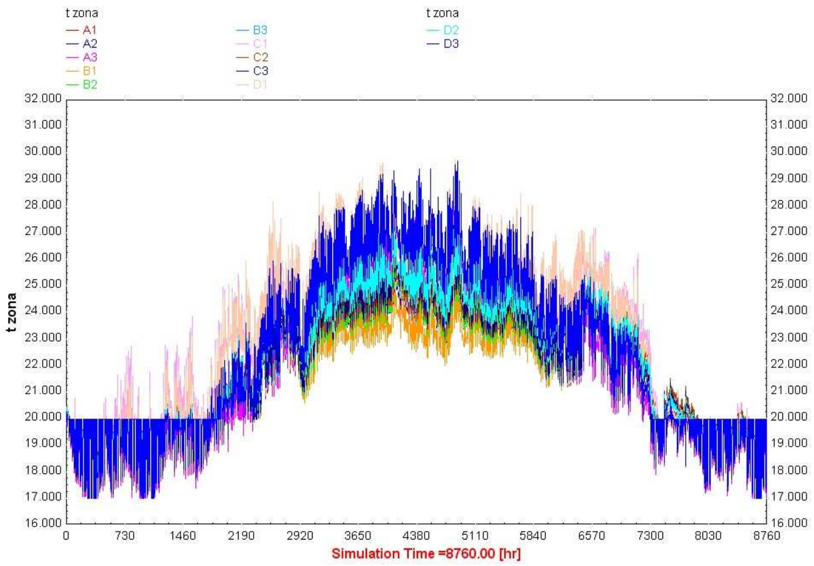

Figure 2. Annual indoor air temperature zoning

There can be noticed that the internal temperature sometimes exceeded 29 °C during the summer period which lead to uncomfortable conditions in the building. There were predicted the windows fixed shading devices in Latvian passive house model, the operation of which depends on the intensity of solar radiation. The same system was reserved in the current research. However the windows shading system must be connected not only with solar radiation intensity, but also with indoor environment in the future for better control possibilities of shading devices. In the current research it was presumed, that occupants had the possibility for individual control of internal shading devices, therefore, it may be said, that there were possibilities to achieve acceptable internal comfort.
There was no passive cooling provided to get occupants satisfaction on hot summer days.
The simulation of hybrid ventilation showed that differences in indoor air temperature were small during the cold period because the mechanical ventilation and heating system were in operation mode and provided a specific internal temperature.
The simulation showed that the mechanical ventilation operated in the cold period of the year and the natural ventilation operated in the warm period of the year.

Results

Findings of the current research were described with operation parameters of hybrid ventilation system. Results, which were obtained from the research successful simulations of the hybrid ventilation model, are summarized in table 1.

Table 1

Summary of findings of hybrid ventilation simulations

Parameters	Simulation model			
	Passive house with hybrid ventilation in Latvia (switch temperature +8 °C)	Passive house with hybrid ventilation in Latvia (switch temperature +10 °C)	Passive house with hybrid ventilation in Latvia (switch temperature +11 °C)	Passive house with hybrid ventilation in Latvia (switch temperature +13 °C)
Specific heating energy consumption kWh/m^2 year	17,76	16,45	16,2	16
Months without heating	June, July, August, (heating in May – 1,5 kWh, September – 1,7 kWh)	May, June, July, August, September, (heating in October – 0,09 kWh)	May, June, July, August, September, October (heating in April – 0,02 kWh)	May, June, July, August, September, October (heating in April – 0,2 kWh)
Heat loses in ventilation system, kWh/m^2 year	22,2	18,4	16,5	13,3
Heat loses in ventilation system in heating season, kWh/m^2 year	9,68	2,36	2,2	1,87
Duration of mechanical ventilation system, h/ year	4892	5443	5763	6342
Duration of natural ventilation system, h/ year	3868	3317	2997	2418
Proportion of electricity savings from operation of ventilators within year, % (*)	44	38	34	27,5

* - calculations were made supposed that ventilators had one operating speed without control possibility.

The findings show the interconnectedness of all parameters. If the hours of operation of natural ventilation decrease, the total heat loses in the ventilation system will decrease, but if the heat loses in the ventilation system decrease, the energy consumption for heating needs will decrease also. For identifying the most efficient operation mode of hybrid ventilation, were compared the heat loses in ventilation in heating season, energy consumption for heating and electricity savings from operation of ventilators. The results show that the largest electricity savings were reached with the switch temperature +8°C, but at the same time heat loses in the ventilation system during the heating season were huge, comparing to other simulations results. That means, when the natural ventilation starts to operate, thermal energy is required to keep the necessary indoor air temperature. Simulation results with the switch temperature +13°C showed the smallest heat loses in ventilation; however the energy savings from operation of ventilators decreased substantially. At switch temperatures +10°C and +11°C the results were similar.

Conclusions

The hybrid ventilation created in the current research operates as a changeover system, whereby the natural ventilation subsystem operates above the control temperature – in the warm period of the year, the mechanical ventilation subsystem operates below the control temperature – in the cold period of the year. The mechanical ventilation system is built with a heat recovery device to save more energy.

The findings of the research show that hybrid ventilation system is able to operate efficiently. At control temperatures 8, 10, 11 and 13°C the analyse of operation simulations demonstrates, that at temperatures +10°C and +11°C the ventilation performance is more efficient than with other temperatures.

Possible savings of electricity are calculated using the simulation results about operation time of each subsystem. In the case of stated most efficient operation of hybrid ventilation, the possible savings can reach up 38% of consumed electricity for ventilators, compared to conventional mechanical ventilation, which operates the whole year.

The analyse of ventilation operation modes shows, that the system does not work in line with the heating system, because the heating system was built in the subprogram TRNBuild in the existent Latvian passive house model and it is not possible to coordinate operation of both systems.

The current research proves that hybrid ventilation is one of the most energy efficient methods for providing good thermal comfort and saving energy.

In the future research should be done about stating possible energy savings, coordination of ventilation and heating systems, creating control system of windows shading devices and heating system in the program TRNSYS Simulation Studio, with using passive cooling and prediction of initial costs.

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Kazinovska G., Blumberga A., Kamenders A., Hibrīdventilācija pasīvajā ēkā Latvijā.

Veiktajā pētījumā ar datorprogrammu TRNSYS ir veikta hibrīdventilācijas sistēmas simulācija. Hibrīdā ventilācijas sistēma ir izveidota un piemērota pasīvās ēkas modelim, kas atbilst Latvijas apstākļiem.

Detalizēti apskatot hibrīdās ventilācijas darbības principus un balstoties uz gūto pieredzi dažādās pasaules valstīs, pētījumā ir aprakstīta hibrīdventilācijas sistēmas izveidošana un tās darbības prognozēšana Latvijas pasīvās ēkas modelī. Ventilācijas sistēmas darbība veidota tā, lai izvairītos no mehānisko gaisa kondicionēšanas iekārtu izbūvēšanas un izmantošanas ēkā. Hibrīdajai ventilācijas sistēmai apakšsistēmu ieslēgšana un izslēgšana tiek vadīta pēc ārgaisa temperatūras, savukārt katras apakšsistēmas intensitāti nosaka apdzīvotībā ēkā.

Pētījumā izveidotās sistēmas darbība ir analizēta, apskatot ventilācijas darbības režīmus pie dažādām āra gaisa temperatūrām, un salīdzinot iekštelpu gaisa temperatūru, enerģijas patēriņa apkurei, siltuma zudumu caur ventilāciju un ventilācijas katras apakšsistēmas darbības ilguma izmaiņas.

Iegūtie rezultāti rāda, ka hibrīdā ventilācijas sistēma Latvijas pasīvās ēkas modelī strādā efektīvāk nekā mehāniskā ventilācijas sistēma.

Kazinovska G., Blumberga A., Kamenders A., Hybrid ventilation in passive house in Latvia.

In the current research a simulation of hybrid ventilation system has been developed. Hybrid ventilation system is created and adapted for a passive house model that corresponds to meteorological conditions in Latvia.

Taking into consideration the explored particular principles of hybrid ventilation systems and case studies in different countries of the world, the current research describes hybrid ventilation system development process and provides analysis of its performance forecast in the passive house in Latvia. The ventilation system has been developed without any mechanical air conditioning. Operating mode of both hybrid ventilation subsystems is controlled by outside temperature, and productivity of each subsystem is determined by occupation in the building.

Basing on exploration of ventilation operating modes by changing control temperatures and comparing inside air temperatures and changes of energy consumption for heating, heat loses in ventilation system and operation time of each subsystem, the operation of the developed system in this research has been analyzed.

The findings of the research show that hybrid ventilation system in Latvian passive house operates more efficiently than mechanical ventilation system.

Казиновска Г., Блумберга А., Камендерс А., Гибридная вентиляция в пассивном здании в Латвии.

В проведённом исследовании с помощью компьютерной программы TRNSY реализована симуляция системы гибридной вентиляционной системы. Гибридная вентиляционная система создана и подходит для модели пассивного здания, которая соответствует Латвийским условиям. Рассматривая детализированною принципы действия гибридной вентиляции и основываясь на полученный опыт в других странах, в исследовании рассмотрено создание гибридовентилляционной системы в прогнозирование действия в модели пассивного здания в Латвии. Действие вентиляционной системы устроено так, чтобы избавиться от установления и использования в здании механического кондиционирующего оборудования.

Анализ работы разработанной в ходе исследования системы проанализирована, рассматривая режимы работы вентиляции при различных температурах воздуха и сравнивая температуру в помещении, изменения потребления энергии для отопления, теплопотери через вентиляцию.

Полученные результаты показывают, что гибридная вентиляционная система в Латвийских пассивных зданиях работает эффективнее, чем механическая вентиляционная система.