Acta Simulatio - International Scientific Journal about Simulation
Volume: 3 2017 Issue: 4 Pages: 1-5 ISSN 1339-9640



*Received: 05 Nov. 2017*
*Accepted: 27 Nov. 2017*

# ANALYSIS OF COMBINATION OF NON-TRADITIONAL HEATING AND VENTILATION EQUIPMENT IN LABORATORY CONDITIONS

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***Keywords:*** ventilation, heat recovery, ANSYS, secondary heat gains
***Abstract:*** Paper is dedicated to the issue of heating of the closed areas by using of a ventilation system with forced air supply and heat recovery and floor convectors with installed fans. Experiment and simulation model created in system ANSYS Fluent 14.0. In the simulation as addition were secondary gains included heat gains from the computers and monitors and heat gains produced by the service personal. The result of the experimental measurements as well as the realized simulation confirms the possibility of heating a room only with HRV as well as possibility of heating of it combination with floor convectors.

## 1 Introduction

Energy-efficient buildings are objects which meet all the legislative requirements; however, they are real effective only if they satisfy the requirement of a subjective thermal comfort. If this subjective condition is not met, there is a risk of the deployment of other alternative ways of heating or cooling. An example is the installation of additional equipment such as space heaters, and mobile air conditioning units that may have substantially lower efficiency than the already installed systems of heating, ventilation and air conditioning (HVAC). This way poorly designed systems which on the one hand meet all regulatory requirements, but on the other hand are not subjective comfortable after installing further equipment significantly disrupt the energy balance of the building.

Accurate measurement of thermal comfort is a very difficult task, because it's very subjective measurement. In General, thermal comfort depends on air temperature, humidity, radiant temperature, air speed, the metabolic processes of the individual human being, but also used clothes, on the basis of the subjective sense of man comfort or of Physiology [1-5]. According to the standard ANSI/ASHRAE 55-2010, thermal comfort is defined as "condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation." People's satisfaction with temperature conditions is also assimilated with the comfort of humans and the thermal comfort is a factor should be reckoned with, while design the working environment or conditions of the individual properties and buildings.

The feeling of an individual comfort will be pleasant, when the body of human not overheating, but at the same time, in the case of active cooling are not felt locally decreases the temperature and air flow. An important aspect is the knowledge that, at the same time, the temperature of the skin is not identical at all areas of the body, according to the physiological point of view. Important aspect that affects the distribution of thermal comfort perception is the level of thermal insulation properties of the used clothing. A general idea for thermal comfort is a steady-state environment necessary to maintain a constant body temperature. So, it is necessary to achieve a thermal balance, in which the environment is taken from the human body as much heat as body produce.

The determining factors of the calculation and design of thermal comfort include:

- The rate of metabolism: the energy produced by the human body
- Insulating properties of clothing, the amount of thermal insulation in clothing man

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- Air temperature-ambient air temperature
- Radiant temperature-weighted average of all the temperatures of surrounding surfaces
- Air velocity-the rate of speed of the air movement
- The relative humidity

Environmental factors include temperature, radiant temperature, relative humidity and velocity of the air. Personal factors are the level of activity (metabolic rate) and clothing.

Thermal comfort is calculated as the energy balance between the heat transfer from radiation, convection and conduction which are balanced by metabolism. Heat transfer occurs between the outside environment and the human body with the average calculated area of 1.81 $m^2$. If the heat transfers from the human to environment more than in the other direction, one sees it as a "cold". If the heat transfers from environment to the human more than in the other direction, one sees it as a "warm" or "hot" [6-10]. Literature [10] also defines the state of the thermal comfort as such when body does not feel heat or cold. From the foregoing, in order to create suitable conditions for the well-being of a person, it is necessary to ensure the required state of the environment. Among the particular factors affecting the thermal state of the environment in relation to the person are: (1) air temperature, (2) the temperature of the surrounding areas, (3) humidity, (4) air speed. The feeling perceived from any single part of the body will depend on the time of exposure, the place and the used clothing, as well as the ambient temperature.

## 2 Materials and methods

Experimental study was made in a laboratory of renewable energy, Department of process engineering at the Technical University in Košice, Slovakia. The plan of the laboratory is shown in Figure 1. Air exchange in the laboratory is provided with ventilation recuperation unit. Air injection and exhaust pipes are located at the celling of the room. Fresh air is supplied to the laboratory through the pipes 1 of rectangular cross section with the gradual reduction of the cross-sectional area of the pipe line to ensure the necessary dynamics of air flow. The exhaust air is going out through the pipes 2.

From Figure 1, it follows that the first air canals have two diffusers, while the second has three. Diffusers are placed in such way to be in front of the axis of the centre of each window. HRV heat recovery unit (Sabiana ENY 3) is located in the next room. Configuration of the HRV allows preheating of fresh air by using an integrated hot water exchanger or an integrated electric heater in the case when the temperature of the intake fresh air from outside is low and recovery process itself would not be enough to raise the temperature to the desired value, in the winter period. System of regulation and control is guaranteed by the DESIGO program, Siemens, figure 2.

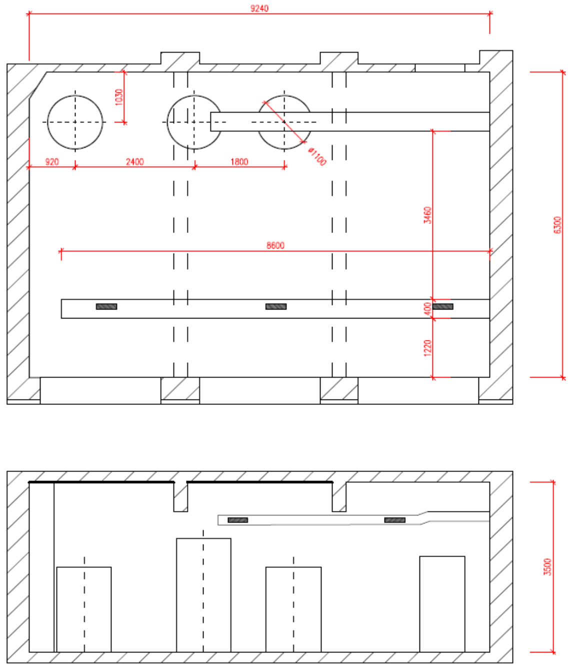


*Figure 1 Laboratory of renewable energy sources.*

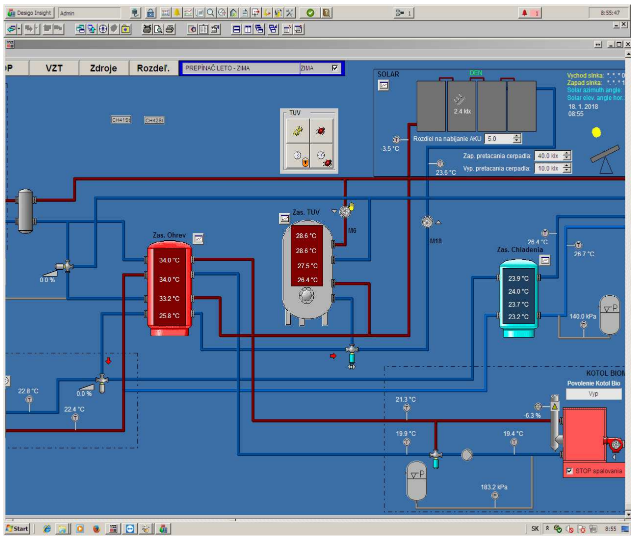

*Figure 2 Visualization of the monitoring data.*

The temperature in the lab according to EN 12831 should be 20 °C.

Thermal characteristics of the building elements, Windows, walls, floor and ceiling have been set according to their technical documentation.

- The thickness of the inner walls is 200 mm and the temperature is 22 °C.

- The outer wall has a thickness of 500 mm and the average temperature of the of the wall is 18 °C.
- The Windows are plastic with double glazing, the surface temperature is 12 °C.
- The ceiling and floor have a thickness of 300 mm and a temperature of 22 °C.

The main sources of heat in the laboratory are floor convectors with axial-radial fans, which are installed in the line below the windows. The surface temperature of the heating elements in the heating period is 42-45 ° C. Control panel of the convectors allows you to regulate the performance by the three-gear system; fans can be operated also in passive mode. This mode allows you to take advantage of convectors as the conventional radiators. In the laboratory installed three storage tanks (Figure 1) for the solar system and the boiler for biomass. The heat loses form storage tanks represented as thermal gains to the laboratory. The tanks are insulated with mineral wool with a thickness of 100 mm. Surface temperature during the day, in the first tank (located at the corner of the room) is approximately 24.5 ° C, the second – 23,5 ° C, the third –, 22 ° C. The average temperature of the water inside the containers is about 37.5 ° C in the first tank, 32 ° C in the second and 25 ° C in the third. The laboratory is also the workplace consisting of six tables with computers and monitors. Location of the computers is on the floor under the desk. Due to the fact that the PC workstation, have significantly higher consumption of energy, their thermal gains is around -100 W/m2. This parameter was included to the simulation model. Heat gains from the monitor are 50 W/m2.

3D model of the laboratory was created by using ANSYS design modeller, which provides a stable calculation and eliminates inaccuracies in the geometry, which can arise when importing from another CAD software. To achieve better quality of the calculation mesh has been selected ANSYS mesh solver. For calculation were used „proximity and curvature advanced size function with fine relevance centre, active assembly initial size seed, high smoothing and slow transition". According to the settings model has 2 958 471 elements. A simulation model also includes simplified models of human bodies with average surface temperatures of 36 °C.

## 3 Simulation

A simulation model of the heating and ventilation has been created in the program of ANSYS Fluent 14.0. For complex simulation were selected models for energy calculation, flow calculation - K-epsilon model and radiation model p1. The air input was chosen as velocity inlet with the input speed of 0.2 m/s and medium temperature 19 ° C. For the outlet was selected pressure outlet. All parameters were set according to the technical documentation of HRV and thermal comfort standards. Research of the parameters of heat recovery ENY 3 was not the purpose of the current work. Figure 3 illustrates the "streamlines" of fresh air flow and temperature contours of the laboratory.

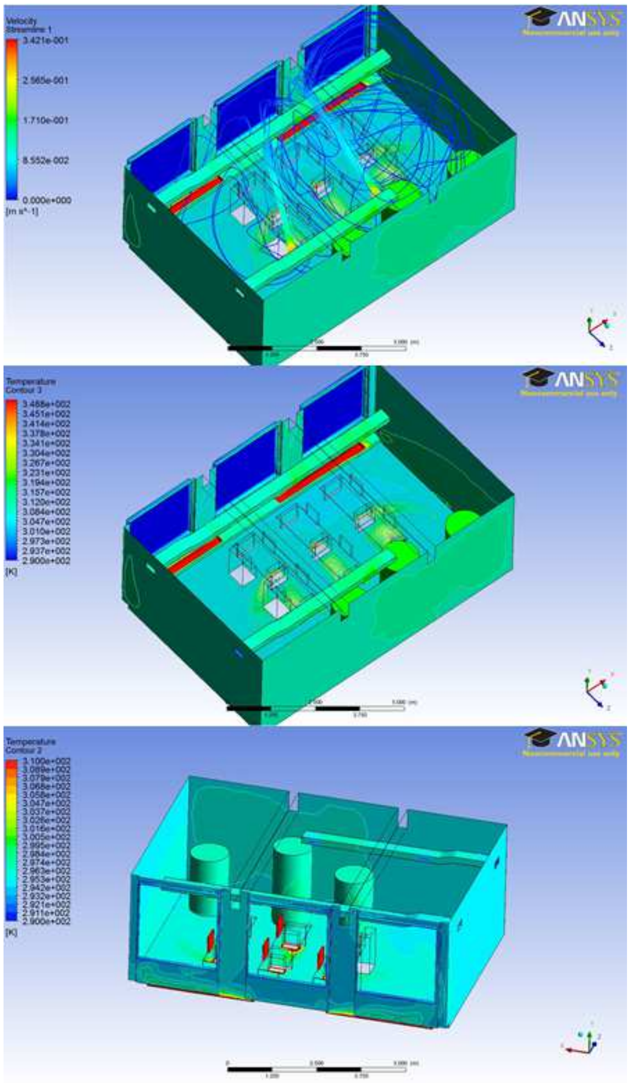


*Figure 3 Simulation results*

The shape of the canal (pipe) and air diffusors as well as the air speed causing turbulent flow of air masses in major part of the laboratory space. The maximum speed of the fresh air is 0.36 m/s, which is much lower than the max value provided at EN 12831.

The lower part of Figure 3 shows the heat flow and temperature on the surface of the walls, windows and floor. Entering fresh air acts as a thermal barrier between the

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windows and the rest area of the laboratory. This is possible due to the difference of the temperatures of the inlet air and the walls.

Fresh air, after entering give certain amount of heat to the exterior and drops to the floor surface, where convectors are located. After heating the air goes up, where it mixed with the original air and subsequently divided into two streams. The first stream is circulated with fresh air. The second is exhaust to the canal with the bad air. The air circulation in the laboratory is in terms of the dynamics of the streams is time-stable, and as result has relatively constant temperature of the mixture in each of the volume parts of the room.

The internal air temperature according to the measurements by the thermometers and installed heat sensors is 22 °C. According to the simulation temperature is 21.8 °C, which is 99% accuracy of the result. The difference between the results is affected by simplifying the heat transfer through the wall. Simulation of the wall heat transfer does not account with the parameters of thin layers, such as colour. The surface temperature of floor was lower versus the upper half of the laboratory only by 0.4 °C.

Also, was made simulation of the laboratory heating only with HRV (fig. 4). To do it, the temperature of the inlet air was increased to 22 ° C (the corresponding value according to EN 12831). It follows from the results of the simulation and figure 4, floor convectors have a significant effect on temperature and air flow masses in the laboratory.

The temperature change is visible in a vertical layout. The temperature of the floor layers is lower by 2 °C compared to the temperature in the upper part of the room. Reduction of the temperature has changed the air circulation in the room floor. The average internal temperature has remained unchanged of approx. 20.8 °C. According to studies are confirmed conclusions [11-14] of the convenience of using multithreading systems for reaching better thermal comfort conditions. As is apparent from the implemented measurements and simulations even small changes in the thermal equipment layout have a significant impact on the temperatures map of the area.

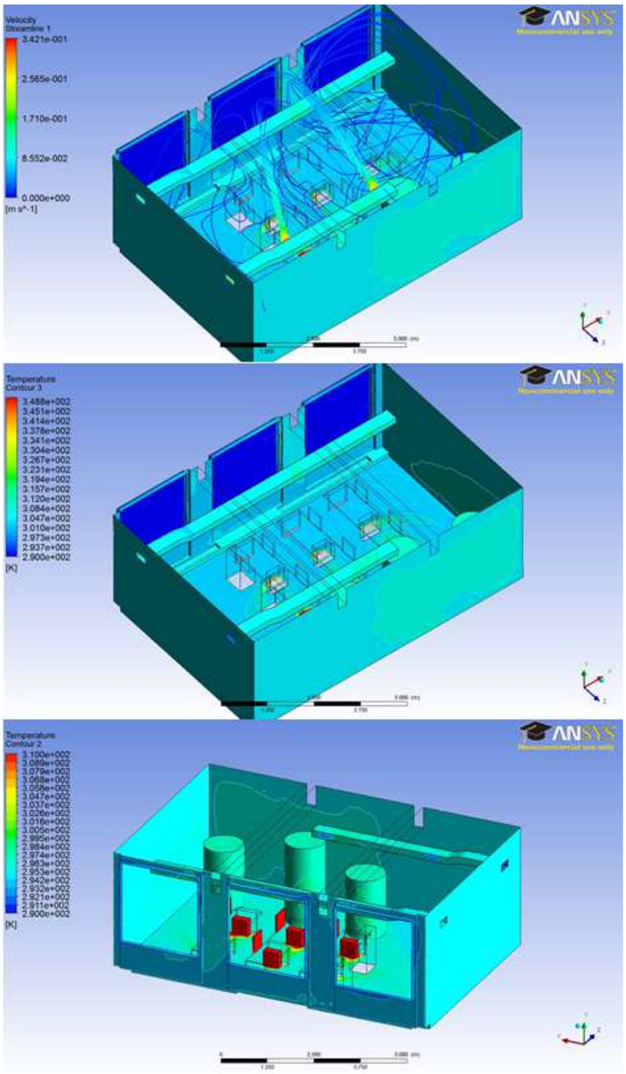


*Figure 4 The results of the simulation with the disabled floor convectors*

## Conclusions

The result of the experimental measurements as well as the realized simulation confirms the possibility of heating a room only with HRV. A side effect of the above solutions is the vertical gradient of temperature layout. This layout is inappropriate, especially in its geometry, with a drop to down, which can significantly affect subjective thermal comfort. According to the results of the simulation the temperature in the lower half of the laboratory was about 2 °C lower than in the upper part of the room, where the temperature of the exhaust air was 22 °C. Heating with floor convector, shows a 60% decrease in the temperature difference, i.e. the room temperature differential felt to 0.4 °C. It also follows from the simulations that the decrease of the floor temperature reduces the circulation in the whole room, as a result of which the efficiency of the air exchange, which leads to its quality reduction.

**Acknowledgment**
This paper is supported by the VUKONZE - Research Centrum for Combined and Renewable Resources of Energy ITMS code: 26220220064

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Single-blind peer reviewed process by two reviewers.