STUDY OF GASEOUS FLOWS IN CLOSED AREA WITH FORCED VENTILATION

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According to the latest researches there are no doubts about the influence of indoor air temperature on the human body. In the current work was made simulations of heating the laboratory in the winter period by heat recovery ventilator (HRV) and combined system of HRV and floor radiators. According to our research it is better to use multi heating systems in terms of comfort people being. It is possible to heat the rooms only by HRV but it may result temperature differences on the high which may be uncomfortable for people. Simulation of the ventilation in the laboratory was made in ANSYS Fluent 14.0.

KEYWORDS

heat recovery ventilator, ventilation, heating, recuperation, ANSYS

1. INTRODUCTION

Nowadays the ventilation systems becoming more and more complicated.

The person feels comfort when the body loses the same amount of heat as it produces. Violation of thermal comfort the person feels firstly comparing with other conditions [Napp 2015]. The feeling of thermal comfort in the room is very individual. Thermal comfort is one of the main conditions for a healthy microclimate of the building [Moftkhari 2017].

People lose heat in next proportion:

- 35% through heat conduction and convection;
- 35% through thermal radiation;
- 24% through evaporation;
- 6% with breathing.

These proportions vary with temperature [Hu 2017]. Integrated temperature indicator of human comfort is not only the actual temperature but perceived which depends not only on indoor air temperature but also to the next factors:

- temperature of thermal radiation;
- air humidity;
- air velocity.

According to the [Szekyova 2004] next factors affect internal climate in the room:

- Air composition;
- Air temperature and other thermal conditions;
- Air humidity;
- Air velocity;
- Noise;
- Light radiation;
- Electric and magnetic conditions.

Nowadays comfort indoor temperature is supported by automated systems of heating, ventilation and air conditioning [Mikeska 2015]. But still there is a problem of ventilation in extreme outdoor temperature, especially in small buildings [Panda 2014] . We cannot avoid ventilations but too hot or cold outdoor air makes indoor parameters uncomfortable for some time periods [Dixit 2015]. To avoid it the modern ventilation systems have integrated recuperations units - Heat recovery ventilators (HRV) [Szekyova 2004]. A HRV is similar to a balanced ventilation system, except it uses the heat in the outgoing stale air to warm up the fresh air [Aydin 2017] [Zhang 2017]. At the Figure 1 you can see the main principle of HRV work.

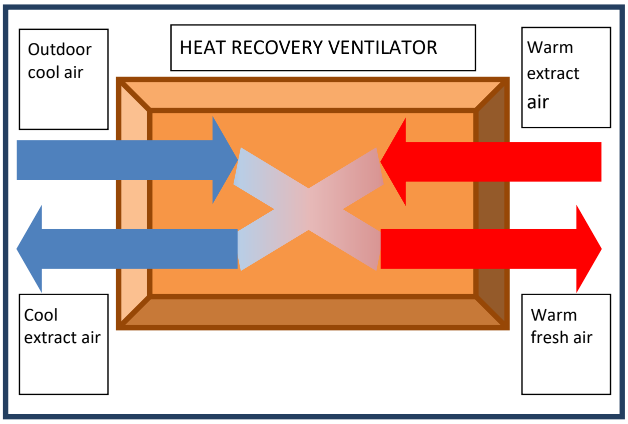

Figure 1. Model of HRV

In the current article we will simulate the ventilation of the laboratory using of HRV and floor radiators in winter conditions.

In middle Europe conditions for average person who is not working appropriate temperature in the room is 18-22°C in the winter period and 23-25°C in summer period. Differences of the temperatures between had and legs layers should not be higher than [Flimel 2014] [Szekyova 2004]:

- 2°C standing man;
- 1.5°C sitting man.

2. MATERIALS AND METHODS

The room under the study is a laboratory of the renewable energy sources of the Technical University in Kosice. The technical drawing of the laboratory is on the picture.

As you can see from the Figure 2 there are tree thermal storage tanks is the laboratory. The ventilation of the laboratory is going through ventilation canals in the upper part of the room. Fresh air comes to the laboratory via canal 1 and goes out through the canal 2. As you can see from the picture first air canal has two nozzles while the second air canal has three situated approximately at the middle of each the windows. The HRV unit (Sabiana ENY 3) is situated in the room next door. The configuration of ENY 3 allows heating fresh air in winter period by hot water or integrated electric heater when heat potential of exhaust air is not enough.

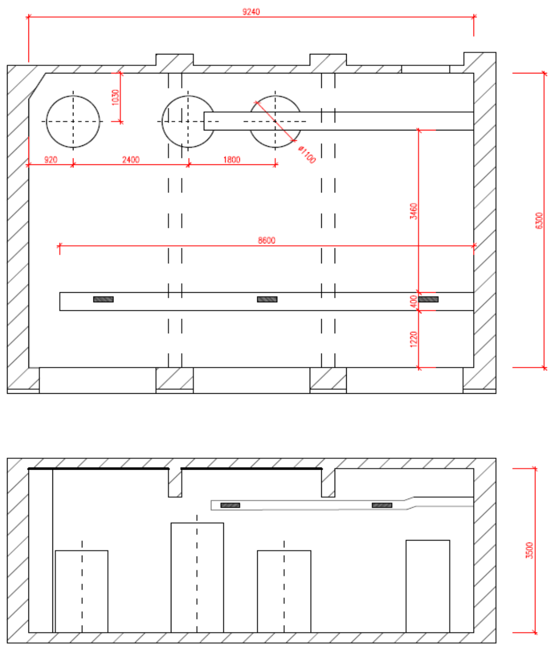

Figure 2. Laboratory under the study

According to EN 12831 the temperature in the laboratory must be 20°C [Krenicky 2010].
Thermal characteristics of the walls, windows, celling and floor are chosen according to their technical documentation.
Internal walls have 200 mm sickness and 22°C temperature.
External wall has 500 mm sickness and temperature in the middle of the wall was 18°C.

Windows have 100 mm sickness and external surface 12°C temperature.

Celling and floor have 300 mm sickness and 22°C temperature.

The laboratory is heated by two floor radiators which are installed under the windows. In winter period the surface temperature of radiators is 42 °C. It is impossible to complete turn off the heating of the laboratory as through the flor radiators provided the whole heat distribution system of the building. Also some heat achieved through the thermal storage tanks. The tanks are isolated by special fibrous material of 10 cm sickness. The surface temperature during the day of the first tank (in the corner) is around 24.5 °C, second – 23.5°C, third — 22°C. The temperature of hot water inside the tanks is approximately 37.5°C for the first tank, 32°C — second, 25°C — third.

3D model for simulation the ventilation in the laboratory was made according to the technical documentation of the building and used equipment. Model was made by using only ANSYS design modeler to eliminate possible inaccuracy of the geometry which may occur by importing it to ANSYS design modeler from other non ANSYS programs.

ANSYS mesh solver was used for making the mesh (Figure 3). To reach better mesh quality was used proximity and curvature advanced size function with fine relevance center, active assembly initial size seed, high smoothing and slow transition. Due to relatively big interior dimensions comparing with the air ventilation canals was chosen 1.30 elements growth rate. According to this setting we had 2,040,256 elements in model.

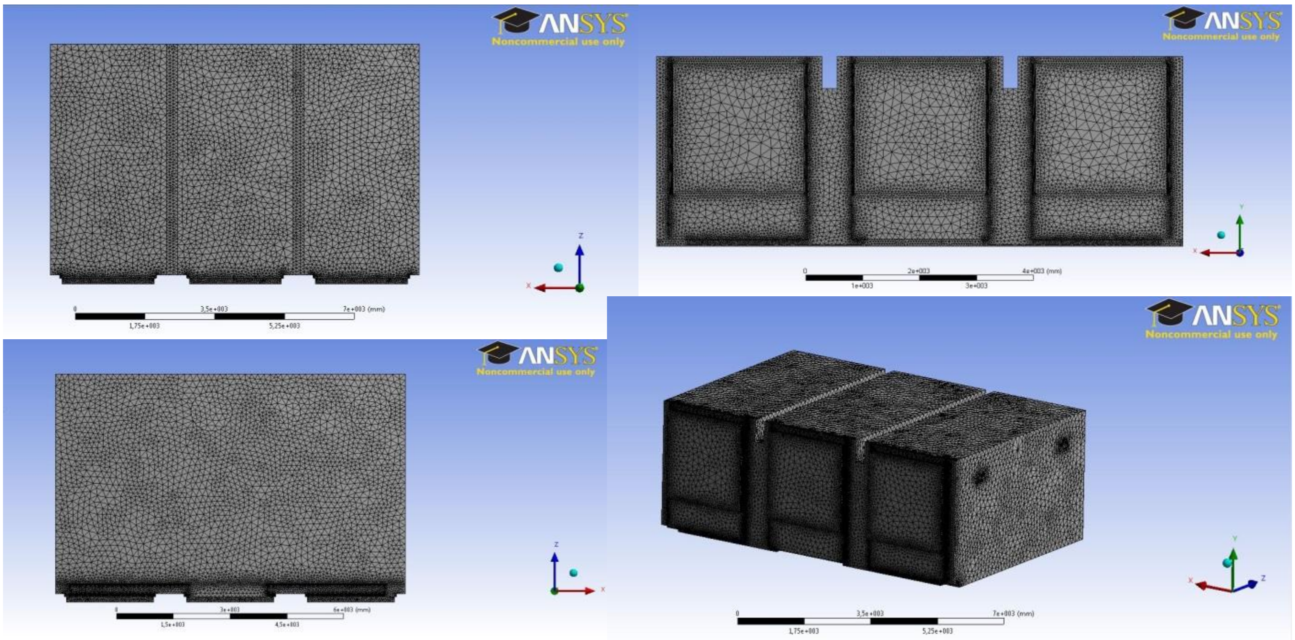

Figure 3. Model with mesh

3. SIMULATION

Simulation of the ventilation in the laboratory was made in ANSYS Fluent 14.0. To simulate the ventilation was used energy equation model, standard K-epsilon model and radiation p1 model [Pedersen 2017]. Inlet type was chosen as velocity-inlet with velocity magnitude 0.2 m/s and 19°C. Outlet type was pressure outlet [Jandacka 2015]. These parameters were chosen according to the technical documentation of the HRV. The research of the heat recovery in the ENY 3 is not a purpose of the current work. The results of the simulation are on the picture. At the upper part of the picture illustrated the streamlines of fresh inlet air (Figure 4).

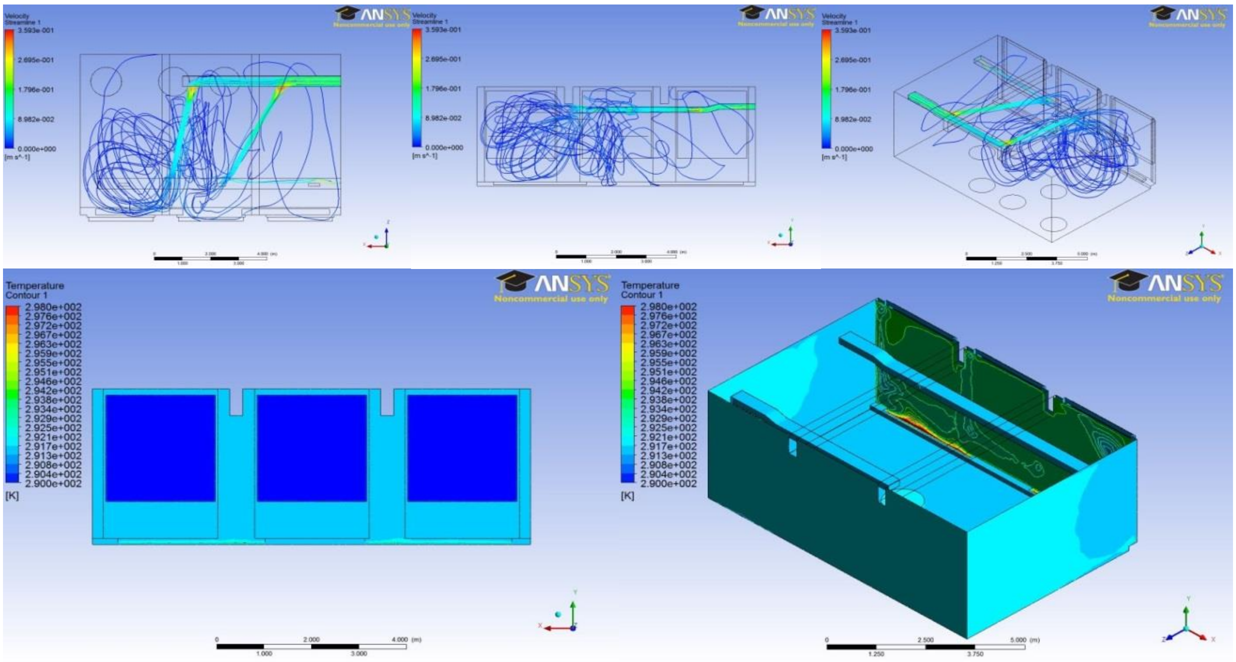

Figure 4. Results of the first type simulations

The shape of the ventilation canal and the nozzles also as a velocity of the air causes the turbulent stream at the half of the laboratory. Nevertheless the maximum velocity of the fresh air is 0.36 m/s what is much lower than it limited by EN 12831.

At the down part of the picture illustrated temperature contours at the surface of walls and windows and at the surface situated at the middle of the floor radiators. The fresh air when it flows into the room plays like heat isolator between the windows and other space of the laboratory. It is possible due to the difference between the temperatures of the inlet air and windows.

After the fresh air transfer some heat to the windows it goes down to the floor radiators where it heated. Than air flow goes up where divided on two streams. The first stream recirculates with the fresh inlet air. The second goes out through the outlet canal with polluted air. Due to such recirculation of the air in the laboratory the temperature is approximately stable in the inside area.

The internal temperature of the laboratory according to the thermometers is 22°C. According to the simulation it is 21.8°C. The reason of difference between the results is simplification of the heat transfer through the wall. In the simulation when was set the parameters of wall heat transfer we do not consider the thin layers as for example paint. Temperature of the celling layer was lower than in the upper half of the laboratory only by 0.4°C.

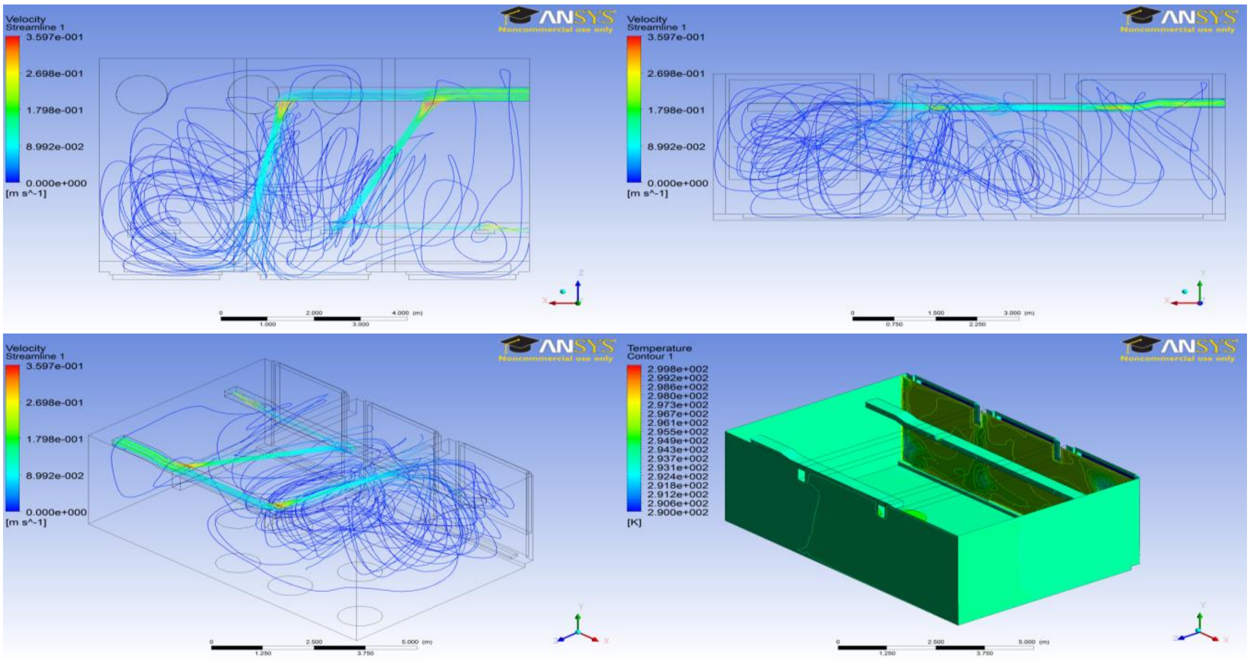

Figure 5. Results of the second type simulations

It was also simulated the heating scheme of the laboratory using only HRV (Figure 5). For this purpose the temperature of the inlet air was increased to 22°C to match the EN 12831. As it illustrated on the picture the absence of the floor radiators have significant influence on the temperature contours and streamlines. Temperature of the celling layer was 2°C lower than upper part of the room. Decreasing of the celling layer temperature reduce the intensity of recirculation. Nevertheless the average internal temperature in the laboratory does not change significant. It decreases by 0.2 °C as temperature in the upper part of the laboratory increase to 22°C.

It is not comfort to have the different temperatures on high of room. Even such insignificant difference of the temperature may reduce employability.

4. CONCLUSIONS

The theoretical and experiential knowledge which you can read above allow understanding and calculating the new ventilation and heating systems respect to its advantages disadvantages. According to our research it is better to use multi heating systems in terms of comfort people being.

It is possible to heat the rooms only by HRV but it may result temperature differences on the high which may be uncomfortable for people. According to our simulation the temperature in the down half of the laboratory was 2°C lower than in the upper half when inlet fresh air temperature was 22°C. Comparing with it by using the floor radiators was possible to reduce this temperature differences by 60% to 0.4°C. By lowering the temperature in the down part of the room will decrease circulation of the air in the whole room.

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