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EXPERIMENTAL INVESTIGATION OF HEAT FLUX AT THE PANEL HEATING SYSTEMS

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Abstract: This paper aims to conduct the experimental research of heat flux of panel heating systems. Also, the aim of paper is to examine the performance of the newly developed concept „floor-ceiling "heating. The study was conducted in the laboratory condition in the cooling test chamber that has the ability to work at temperatures lower than 0°C. As output parameters were used: electricity consumption for operating the heating panel and the indoor temperature of test model. Test model was investigated at the Faculty of Engineering at Kragujevac. Also, this research is part of the project „Development of net-zero energy houses.
Keywords: panel heating; floor-ceiling heating; heat flux; experimental

INTRODUCTION

In Serbia, the panel heating systems are relatively well-known concept. However, as a result of lack of information as well as engineering prejudice to their right application is still waiting. It is known that panel heating systems due to its mechanism of heat transfer, provide the best thermal comfort. However, in scientific circles, there are many controversies that the panel system has the best characteristics.

This research is a continuation of previous numerical investigations of panel system. In addition to the standard types of panel heating (floor, wall and ceiling heating) in previous research to come to a new concept of "floor-ceiling" which proved to be more energy efficient compared to other panel heating systems [1].

This paper aims to conduct the experimental research of heat flux of panel heating systems. Experimental procedure was conducted on the test model consisted of two rooms (storey). The heating panels are made of the electric heating cables. External conditions are kept constant in the cooling chamber at the temperatures of 4.5°C. The measurement was conducted for wall heating panels, ceiling heating panels, and floor-ceiling heating panels.

EXPERIMENTAL PROCEDURE

Experimental study of the characteristics of panel heating systems was performed at the Faculty of Engineering Sciences in Kragujevac, partly in the Laboratory of Thermodynamics and Thermal Engineering, and partly in the Laboratory of Motor Vehicles.

The experimental installation includes a test chamber, the test model of the house, measuring and control equipment for data collection.

The dimensions of the test chamber were 1500x1500x1800 mm and it placed inside the room dimensions 3500x5500x3800 mm (Figure 1).

Figure 1. The test chamber

Test chamber works on the cooling chamber principle which contains two evaporators associated with air chiller. Chiller on the condenser side uses air from the room located within the test chambers. The test chamber has the ability to cool until -15°C however, due to the work of the chiller inside the building in which the chamber was located and due to the low rate of air change in the room leads to overheating of the air and it is not advisable go to temperatures below -5°C. The temperature of the test chamber was controlled by PID controller type

XMTF-308 product Yuyao Gongyi Meter Co. Ltd. [2], which is connected to the PT100 probe. The humidity and temperature inside the test chamber was measured by the sensor of temperature and humidity type TSN-TH70E product "AREXX Engineering" Netherlands [3]. This sensor used "wireless" connection to communicate with the computer.
The test model was consisted of two stairs that are placed one above the other so that each represents one room which was heated. Dimensions of the test model were 1000x800x650 mm where the room height was 650 mm. In addition, each stair has one opening on the side which glazed with Plexiglas dimensions 300x250 mm. This opening has the function of the window and also has the function of an inspection opening. In this experiment investigated four types of panel heating systems was used: floor heating, wall heating, ceiling heating and floor-ceiling heating. So the test model has the ability of the simulation any of the mentioned systems, and in each of the room the wall panel and floor panel was built and by rotation of the rooms for 180 °C floor panel become to the ceiling and vice versa (Figure 2).

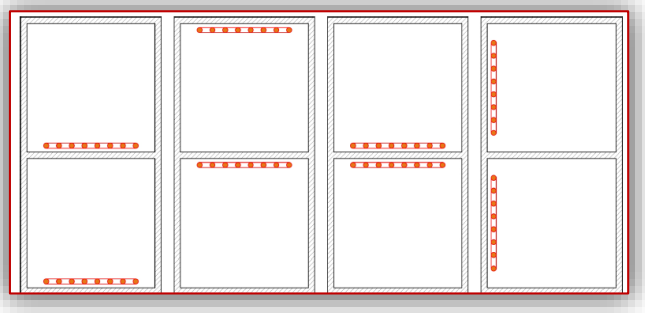

Figure 2. Analyzed panel heating systems

MEASURING PROCEDURE

Figure 3 shows the installation for measuring of the heat flux that consisted of auto-transformers, regulators associated with the PT100 temperature probes, computers for data collection and flux meter type "Hukseflux TRSYS01-F".

Figure 3. The installation for measuring heat flux

Figure 4 shows the test model that was connected with the sensors of the temperature and heat flux. At the same time was measured heat flux on both sides of the structure. This was possible because the used flux meter has the two pairs of sensors for determining the heat flux. Figure 5 show software used for data collection from the measuring sensor. In each time it was written the data of the contact temperature and heat flux that was passed through the measuring element.

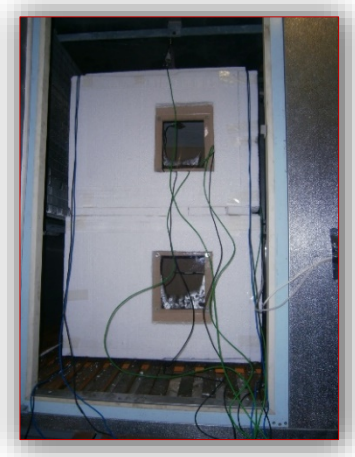

Figure 4. The test model conneceted to the measuring installation

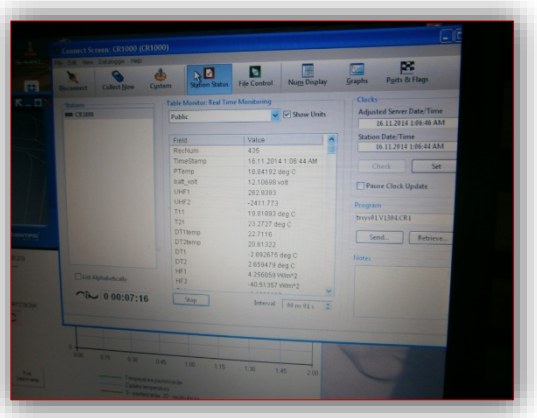

Figure 5. Software workspace for data collection

Figures 6 - 8 shows the measured values of surface temperatures and heat flows for wall, ceiling and floor-ceiling heating.

- Wall heating (Figure 6). The internal temperature of the surface of the wall panels when the heating was in excess of 34°C, while the surface temperature on the outer side was about 5°C which was the ambient temperature. The value of the heat flux from the inner side of the panel (Figure 6 a) was in the range of 117 to 125 W/m^2, while the outer side (Figure 6 b) ranged from 17.3 to 19.7 W/m^2.
- Ceiling heating (Figure 14). The internal temperature of the surface of the panels when the ceiling heating was at approximately 34°C, while

the surface temperature on the outer side was about 5°C which was the ambient temperature. The value of the heat flux from the inner side of the panel (Figure 7 a) was in the range of 116.6 to 126.1 W/m², while the outer side (Figure 7 b) ranged from 15.1 to 18.5 W/m².

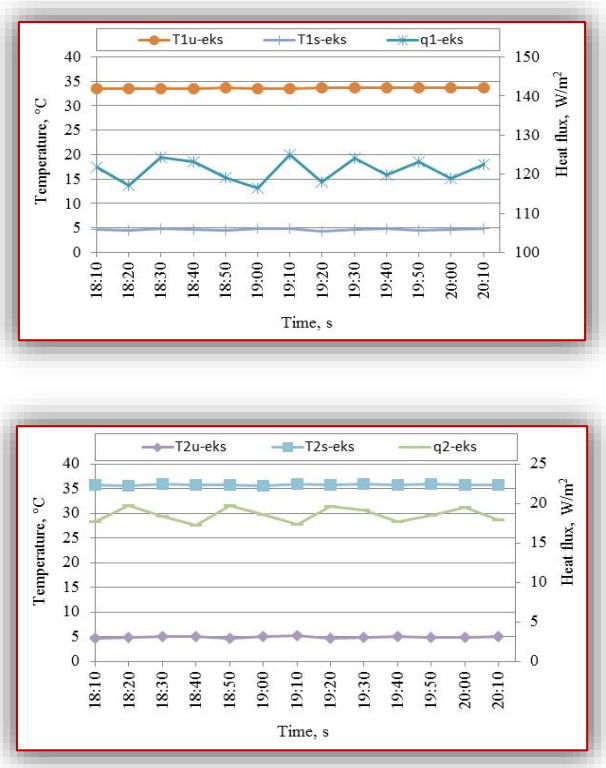

Figure 6. The contact temperatures and heat flux at wall panel on the inner side (left) and the outside (right).

» Floor-ceiling heating (Figure 8). The internal temperature of the surface of the panels when the floor-ceiling heating (temperature of the underside of the panels) was in excess of 36°C, while the surface temperature on the outer side was about 27°C. The value of the heat flux from the bottom of the panel (Figure 8 a) was in the range of 109 to 113.6 W/m², while the upper side (Figure 8 b) ranged from 55.8 to 56.7 W/m².

Figure 9 shows the energy consumption of analyzed heating panels. Consumption are shown at a constant outdoor temperature of -5°C, 0°C and 4.5°C. The ceiling heating has the highest energy consumption: 183.98Wh, 150.64Wh and 122.88Wh at the constant outdoor temperatures of 5°C, 0°C and 4.5°C, respectively. The lowest energy consumption has the floor-ceiling heating about 163.23 Wh, 131.71 Wh and 97.28 Wh at constant outdoor temperatures of -5°C, 0°C and 4.5°C, respectively. Wall heating has a the energy consumption of 180.10 Wh, 145.87 Wh and 114.89 Wh and the floor heating has the energy consumption about 175.04 Wh, 141.25 Wh and 111.58 Wh at constant outdoor temperatures of -5°C, 0°C and 4.5°C, respectively.

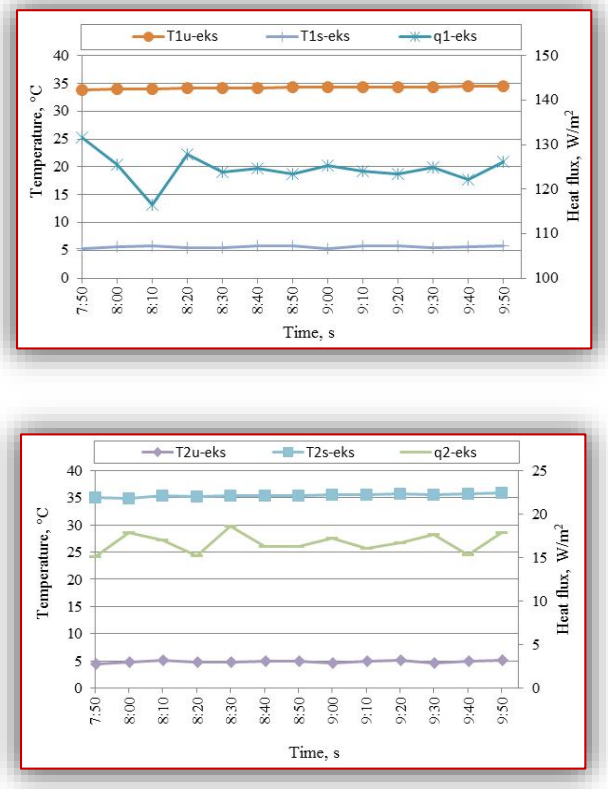

Figure 7. The contact temperatures and heat flux at ceiling panel on the inner side (left) and the outside (right).

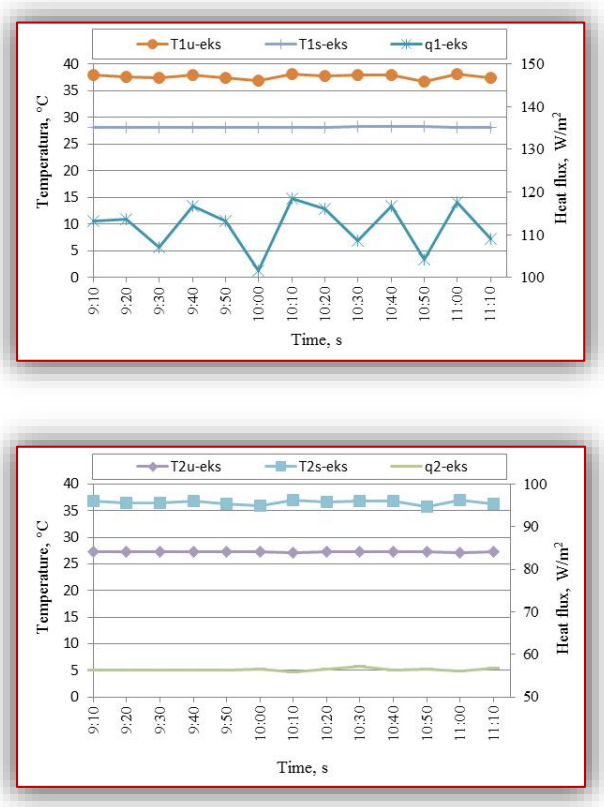

Figure 8. The contact temperatures and heat flux at floor-ceiling panel on the inner side (left) and the outside (right).

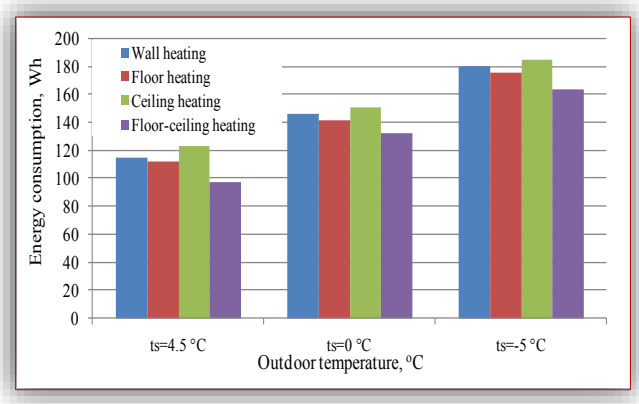

Figure 9. The comparison of energy consumption of panel heating systems (floor, wall, ceiling and floor-ceiling heating)

CONCLUSIONS

In the experimental procedure has been conducted up to identical conclusions as in the previous studies based on numerical investigation. So, floor-ceiling heating panels consume the least energy and ceiling heating panels has the highest consumption.

Within experimental research is also carried out and the measurement of heat flux. So that the value of the heat flux to the indoor environment was approximately 125 W/m^2 for wall and ceiling heating. For floor-ceiling heating value of the heat flux from the bottom side were about 110 W/m^2, and the upper side of about 56 W/m^2. Temperatures on the surface of the panel for the wall and ceiling heating were about 35°C, in a floor-ceiling panel temperatures were about 37°C at the bottom and about 27°C from the upper side of the panel.

Acknowledgment

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Note

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