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THE IMPACT OF THE CONTROLLER POSITION ON THE ENERGY CONSUMPTION AT THE FLOOR-CEILING HEATING

Abstract: *The main objective of this study was to investigate the influence of the position controller of heat at floor-ceiling heating. Earlier defined concept floor-ceiling heating was driven via thermostat the located on the bottom side the panel. While this study was aimed to investigate the case when the floor-ceiling panel was driven from the upper side of the panel. 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; temperature regulation; experimental*

1. INTRODUCTION

Low temperature radiant systems are very complex because they involve different mechanisms of heat transfer, conduction through the walls, convection between the building surface and indoor air, radiation between the panel and surrounding areas and the conduction between the floor area and ground. The main essence of the low-temperature air systems is to provide adequate thermal comfort at significantly lower temperatures and to prevent overheating of the rooms in heating mode.

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].

Earlier defined concept floor-ceiling heating was driven via thermostat the located on the bottom side the panel. The aim of this study was to investigate the influence of the position controller of heat at floor-ceiling heating. 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 -5°C, 0°C, 4.5°C. The measurement was conducted for wall heating panels, floor heating panels, ceiling heating panels, and floor-ceiling heating panels.

2. 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 1500x1500x1800mm and it placed inside the room dimensions 3500x5500x3800mm (Figure 1). Test chamber works on the cooling chamber principle which contains two evaporators (Figure 2) associated with air chillier. Chiller on the condenser side uses air from the room located within the test chambers.

Figure 1 *- The test chamber*

Figure 2 *- The interior of the test chamber – preview of evaporator*

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 (Figure 3) type XMTF-308 product Yuyao Gongyi Meter Co. Ltd. [2], which is connected to the PT100 probe.

Figure 3 *- The sensor for maintaining the temperature inside the test chamber*

The humidity and temperature inside the test chamber was measured by the sensor of temperature and humidity type TSN-TH70E product "AREXX Engineering" Netherlands (Figure 4) [3]. This sensor used "wireless" connection to communicate with the computer.

Figure 4 *- The sensor for the acquisition of temperature and humidity inside the test chamber*

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 1000x800x650mm where the room height was 650mm. In addition, each stair has one opening on the side which glazed with Plexiglas dimensions 300x250mm. 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 5)

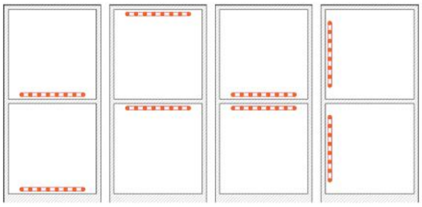

Figure 5 *- Analyzed panel heating systems*

***Figure 6** - The interior of the test model - show the position of the PT100 probe*

The heating panels are made of polystyrene thickness of 50mm, unrefined slab of plywood thickness of 18mm, PVC mats, electric heating cable, cement mortar thickness of 5mm and (Figure 7). Test model in a constructive sense was entirely made by plywood, through which by staples attached PVC mesh with the have the role of laying of the heating cable with raster laying of 50mm (Figure 8). Over the heating cable the thin layer of cement mortar with thickness 5mm was applied, which contributes to a homogeneous temperature distribution along the heating panels.

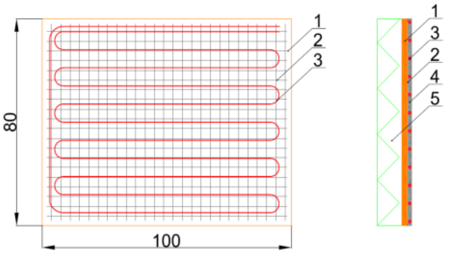

***Figure 7** - Details of panel construction: (1) Plywood panel; (2) PVC grid; (3) electric heating cable; (4) cement mortar; (5) polystyrene*

***Figure 8** - Detail of installation of heating cable*

Construction of **eletricic heating cable** consist of the Heating Conductor, Fluoropolymer Dielectric Insulation, Glassceramic Tape, Nickel-Plated Copper Braid (BN), Fluoropolymer Overjacket. Heat output of the heating cable was 17 W/m, the thickness of the electric heating cable was 3.5mm, and the minimum bending radius was 5D.

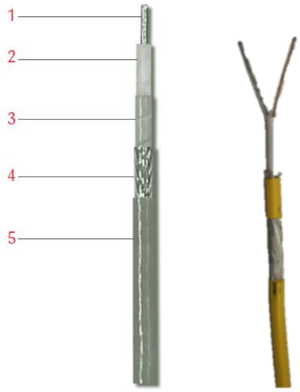

***Figure 9** - The construction of electric heating cable: (1) Heating Conductor; (2) Fluoropolymer Dielectric Insulation; (3) Glassceramic Tape; (4) Nickel-Plated Copper Braid (BN); (5) Fluoropolymer Overjacket*

3. MEASURING PROCEDURE

Measuring procedure is based on measurement of energy consumed in order to maintain a constant temperature within the test model. The test model is placed inside a test chamber, within which is maintained a constant temperature. For the internal temperature of the test chamber were selected three values as follows: 4.5°C, 0°C, and -5°C. The first value was chosen because the average temperature of the heating period for cities in Serbia mainly about 4.5°C. While temperatures -5°C maximum permissible value in the measurement installation. Temperature 0°C the intermediate value between the two above-mentioned values. The heating panels were connected to a heat regulator that regulates the auto-transformer on the principle on/off. Each room of the test model has its own controller, which measures the value by the PT100 probe placed in the middle of room (Figure 6). Temperature regulators were connected to a computer where it is logging the temperature inside the test room of the models and exclusion/inclusion of the transformer. The output from the autotransformer to the heating panel was set to 220V and 0.895 ± 0.005A which gives the overall power of the panel about 197 ± 0.5 W. These parameters were kept constant during the measurement and the control by measuring of the temperature inside the room of test model included or excluded operation of autotransformers.

Test the installation was aimed to verify the accuracy and exam performance of the heating panels prior to their installation in the test model. This was necessary in order of accuracy control of the panels as well as for the determination of the temperature gradient of each panels. Temperature gradient was determined by using the thermal IC camera types i7 product "Flir" [4].

Figure 10 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 163.23Wh, 131.71Wh and 97.28Wh at constant outdoor temperatures of -5°C, 0°C and 4.5°C, respectively. Wall heating has a the energy consumption of 180.10Wh, 145.87Wh and 114.89Wh and the floor heating has the energy consumption about 175.04Wh, 141.25Wh and 111.58Wh at constant outdoor temperatures of -5°C, 0°C and 4.5°C, respectively.

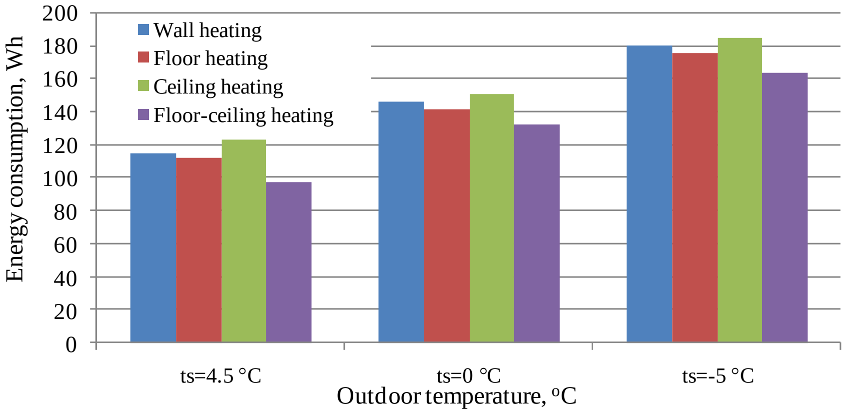

Figure 10 *-The comparison of energy consumption of panel heating systems (floor, wall, ceiling and floor-ceiling heating)*

As the construction of floor-ceiling panel such that the resistance to thermal conductivity from the lower side is the less, the regulation temperature for the floor-ceiling heating system was via a thermostat which located inside the lower storey of the test houses.

Figure 11 shows the comparison of energy consumption for heating between the floor-ceiling panel systems where temperature control is performed by the controller from the lower floors of the test house or when temperature control is performed from the upper floors of the test house. Consumption floor-ceiling panel with the upper regulation is higher than the floor-ceiling panels with lower regulation. That is, the power consumption at the floor-ceiling panels with lower regulation is 163.23 Wh, 131.71 and 97.28 Wh Wh, and energy consumption in floor-ceiling panel with the upper regulation is 176.39 Wh, 140 485 Wh and 99.94 Wh at constant ambient temperatures of -5°C, 0°C and 4.5°C, respectively.

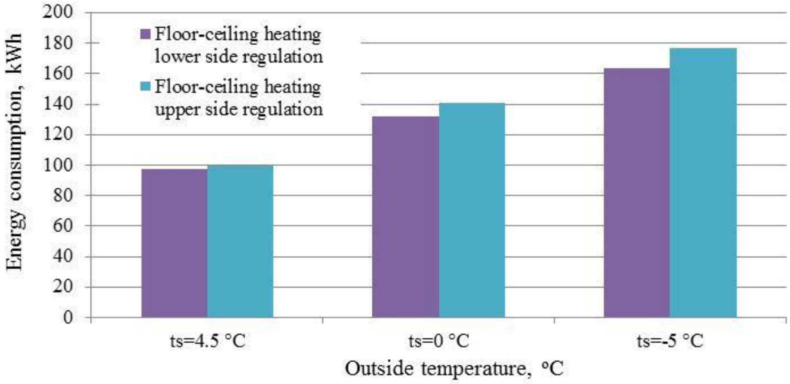

Figure 11 *- The comparison of energy consumption of the floor-celling heating systems with lower side and upper side regulation(floor, wall, ceiling and floor-ceiling heating)*

4. 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.

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So, it can be concluded that the floor-ceiling panels more energy efficient compared to the others panels. Also, a slightly lower temperature can be solved by a combination of regulation from the upper and lower room with dominating regulation of temperature in the lower room.

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