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EXPERIMENTAL PROCEDURE FOR INVESTIGATION OF ELECTRIC PANEL HEATING SYSTEMS

Abstract: *In Serbia is increasingly using of panel heating systems. Besides the commonly used hydronic panels there is an option to use the electric panels for the heating. The main objective of this work is to develop an experimental procedure for testing of the electric panel heating. In fact, elaborate details of the experimental investigation according to the available resources which are dictated by available measuring equipment. Experimental procedure will be carried out in the laboratory of Thermodynamics on Faculty of Engineering at Kragujevac. In this study, besides the usual panel heating system the testing of newly developed floor-ceiling panels is provided.*
Keywords: *radiant panel, experiment, energy consumption, test room*

1. INTRODUCTION

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

Rekstad et al [1] are developed a new approach of temperature control and energy metering in low temperature heting systems. Rahimi and Saberbaeeni [2] are investigated the impact of heated floor on the suroundings surfaces. This research is conducted in test room (2.4x2.4x2.4) equipped with under-floor heating system. Hasan et al [3] conclude that using radiator and floor heating indicate that there is a small vertical difference of air temperature inside the test room, which would not produce any significant thermal discomfort.

This work relies on previous research on panel heating systems. Beside standards panel heating systems (wall, floor and ceiling) Bojic et al [4] are devised a novel panel heating system with name “floor-ceiling” panel

The main objective of this paper is to define an experimental procedure in order to comparison electric low temperature radiant systems. The analysed system are floor panel heating, wall panel heating, ceiling panel heating and newly developed floor-ceiling panel heating. The analysed system will be applied in experimental chamber and the electric panel was connected on electricity supply.

2. EXPERIMENTAL PROCEDURES

2.1 Model of house

The test model would consist of two rooms, which will be located one above the other in order to test a new concept of floor-ceiling heating (Fig. 1). All room dimensions, it is necessary to be the same, in order to examine the effect of the panels on the surrounding area. On figure 2 it showed cross section of test room. The dimension of test model are 1.0x0.8x.0.65m were the each room have a height of 0.65m. The window dimensions are 0.30x0.30m.

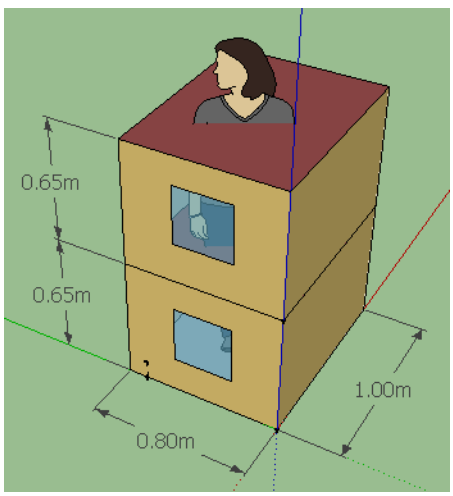

Figure 1 - Experimental house

In this study for type of panel heating systems are investigated (Fig. 2). The first system was floor-heating, the second system was ceiling heating, the third system was floor-ceiling heating and the fourth system was wall heating. The floor-ceiling heating represent newly developed heating system.

House model is placed in the environmental test chamber which can simulate real climatic conditions by having low temperatures set in it. Zones need to be heated with constant power in order to determine distribution of the temperature and air humidity in zones, but also to have good dynamics of reaching the given temperature conditions. Temperature and air humidity measurements needs to done in few characteristic points distributed in zone space. Measurements should be done in small time intervals because of the model dimensions.

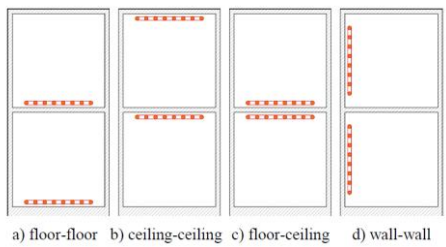

Figure 2 - Examples of the heating panels positioning

The structure of the heating panel is shown in Figure 3. The construction of the model is made of polystyrene, plywood, PVC grid, electric heating cable and plasterboard. On the plywood board (1) is attached the PVC grid (2) which binds the heating cables (3). Over the electric heating cables applied a thin layer of plaster. The plaster layer has the task to create a homogeneous temperature distribution along the plate.

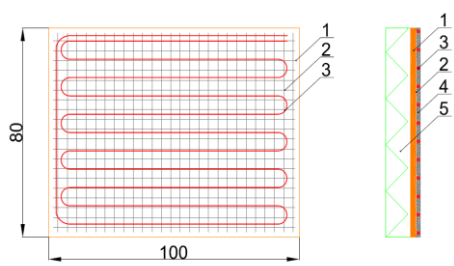

Figure 3 - Detail of panel construction (1) ***Plywood panel; (2) PVC grid; (3) electric heating cable; (4) plasterboard; (5) polystyrene***

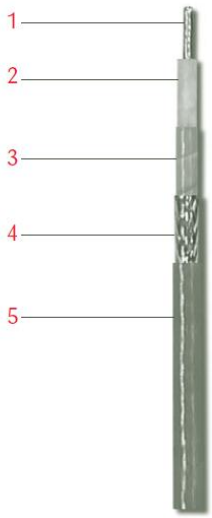

Figure 4 - The construction of heating cable (1) Heating Conductor; (2) Fluoropolymer Dielectric Insulation; (3) Glassceramic Tape; (4) Nickel-Plated Copper Braid (BN); (5) Fluoropolymer Overjacket

On figure 4 the construction of electric heating cable was shown. Construction of heating cable consist of the Heating Conductor, Fluoropolymer Dielectric Insulation, Glassceramic Tape, Nickel-Plated Copper Braid (BN), Fluoropolymer Overjacket.

Table 1 - The characteristic of the electrici heating cable

Characteristic	Values
Maximum Watt density	17 W/m
Maximum supply voltage	700 Vac
Maximum continuous exposure temperature Power-off	260°C
Minimum installation temperature	60°C
Minimum bend radius	5 x cable O.D.
T-rating	T2 to T6

3. MEASUREMENTS PROCEDURES

By connecting the electric heating cable embodied in the experimental model it enables the testing of the heating system for four different types of the heating panels. For heat supplying of the experimental model, the electric cable uses electricity from the grid. Electricity passed through the cable and encountering resistance that have caused to the release of the heat on the surface of the cable. By placing the power meter between the electricity plugs and electric cable can be measured power consumption at any time.

When considering the measurement in the experimental model, it is necessary to monitor the parameters which affect on the thermal comfort in the room. Monitoring of these parameters is based on the setting of the temperature sensor on middle of the room and measures the multiple points vertically in order to define the temperature gradient. It is also necessary to perform the measurement at the furthest points of the tested panels. In addition to measuring the air temperature inside the room and it is necessary to measure the temperature on the surface structure and the determination of the heat flux through the construction of panels. This is necessary in order to determine the impact of the panels to the external environment and identify the best solutions in terms of increasing the efficiency of them.

Measuring installation

Concept of measuring installation for measuring the distribution of the temperature and air humidity in house zones is created according to analyses on the concept of the house models and needed research. Layout of the measuring points of temperature and air humidity sensors is also determined according to measurements of the temperature in real objects given in the literature [5]. Main part of the measuring installation is

environmental test chamber – cooling chamber to -20 °C, with dimensions 1500x1500x1800 mm. Temperature regulation in the test chamber is done by using the PID regulation, which allows precise temperature conditioning in the test chamber.

When distribution of the temperature and air humidity in the zones is measured, heating with constant power of the panels is used. Power regulation of the panels is achieved with thyristor controller with width modulation or by using autotransformer which changes effective voltage of the heater power. Autotransformer regulation is selected in this case because the small power is needed to heat zones of house model. Additional advantage of the autotransformer is because they don't create electromagnetic interference which can influence on the proper work of the measuring installation.

When constant temperature is maintained in the house model zones, heating with variable power of the panels is used. Precise temperature regulation is achieved with thermo regulators with PID regulation. In this mode, characteristics of the used thermal insulation are measured because the constant temperature difference between the air in the environmental test chamber and air in the zones is achieved and maintained.

Power measurement in both cases of panel heater usage is done by using power meter which allows the measurement and data acquisition in predefined time intervals. This allows determination of the energy used for zone heating, assuming that power of the heater panels haven't changed between two measurements. Temperature and air humidity in house model zones are measured with sensors which saves measurements data in internal memory in predefined time intervals (data loggers). Layout of the sensors positions in vertical plane in this measurement installation is given Fig 6.

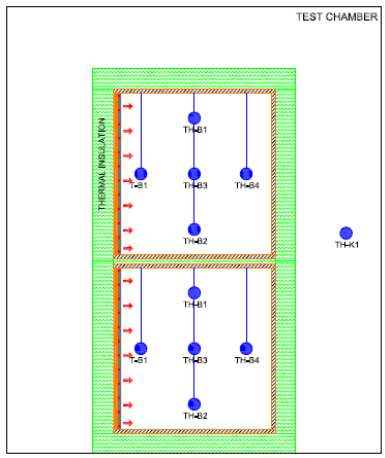

Figure 6 - The sensor position. (T-A1, T-B1- Temperature sensor in circuit of the panel heater thermo regulator; TH-Bx (x=1…4) – Temperature and air humidity sensors in zones; TH-K1 - Temperature and air humidity sensor in environmental test chamber)

Usage of higher number of sensors in order to get more precise picture of the temperature distribution wouldn't make sense as the house model is of small dimensions and it is symmetric. Temperature sensors in circuit of the panel heater thermo regulator are not used as measurement signals but only as control signals.

Figure 7 - System for wireless data acquisition

Sensors shown on figure 7 are sending measurements results through wireless as they have system for wireless data acquisition. Then results are saved in the PC memory. Minimum time interval for measuring is quite large and therefore these sensors are not suitable for dynamic measurements.

Their advantage is because use can track temperature and air humidity changes during the experiment in real time. Measurements results for temperature and air humidity in house model zones, temperature and air humidity in environmental test chamber and heating panel power are independently entered in tables in personal computer. This means that results needs to be time synchronized by setting real time in sensors, power meter and personal computer. Then these results are time synchronized in computer and put in same unique table which is then used for analyzing of the experiment results. By setting same starting conditions, experiment can be repeated under the same conditions and therefore results of the experiment can be checked and verified.

4. CONCLUSION

This paper defines the experimental procedure aimed at testing of electric panel heating systems. Investigated types of panels are floor panels, wall panels, ceiling panels and newly developed floor-ceiling panels.

The procedure is shown that by using relatively simple equipment can lead to quality results. All research will be conducted in a test chamber where it will maintain a constant temperature.

Procedure has shown that a single model can be used for examine of all heating panels. Also, the results obtained by using electric panel systems can be realted with house that use hydronic panel systems.

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