Agronomy Research **13**(2), 494–499, 2015

Hot-air distribution in the floor heating

P. Kic

Czech University of Life Sciences Prague, Faculty of Engineering, Kamycka 129, CZ16521 Prague 6, Czech Republic; e-mail: kic@tf.czu.cz

Abstract. The aim of this paper is to present results of measurement of hot-air floor heating system. The energy from fireplace directly heats the house near to the chimney and partly is distributed by the special ventilation under the floor in the whole heated room. The main principle is based on specially designed accumulative floors, consisting of a set of special chambers, which enable to heated air from the fireplace to flow through them. The layer of concrete floor is installed on the surface of these chambers. Hot-air can be intensively distributed around the house with time shift, but the air flow is not uniform and some places are warmer or colder. The results of measurements in the building showed that the accumulation in the floor compensates temperature differences. The result of proper application of this type of heating is a stable thermal comfort and saving of heating costs. Based on the results of measurements, practical recommendations for the design, installation and use of these types of heating were summarised in the conclusions.

Key words: energy accumulation, fireplace, floor, temperature.

INTRODUCTION

Fireplace is currently very popular equipment of newly built or modernized family or townhouses. For home owners, this investment is attractive for both aesthetic and practical reasons. Fireplace provides traditional wood heating, which is still relatively easily accessible and relatively cheap fuel. Suitable heating system is important for the human comfort in winter, but it the suitable indoor conditions can be important also for a material used for a construction, e.g. durability influenced by the air humidity of timber construction (Papez & Kic, 2013).

Current development of construction and continuously increasing prices of energy compels owners and designers of all types of houses to look for high-quality integrated solutions of buildings including the heating and to optimize the operation, in particular to reduce the energy consumption (Kic & Kadlecek, 2012).

The basic mission of a residential building is to create a healthy and pleasant environment for its residents. For a human organism is very important 'radiation comfort', which means that one should take the heat from the environment predominantly by radiation and remove excess heat from his body by convection (cooling by the flow of ambient air) (Kic, 2013).

Radiation, based on the heating surfaces, impacts the other surfaces surrounding the room and the objects that are inside the room. They are heated and they transmit the heat to people and warm the air in the room (Cihelka, 1961). Now, there are advantages of the utilization of new modern techniques in design (Vio, 2011), but also in economical operation with automatic control, according to user requirements.

The main attention in this research was paid to the function hot air distribution through the special AKU elements, developed especially for this purpose. Another important aim of provided experiments was the control and measurement of heat accumulation in the floor during the hot air supply. There was measured the transfer of energy to the heated space after the stop of heating, and the influence of the radiant heating from the large floor area on the indoor thermal conditions.

The continued improvement of thermal properties of buildings, especially high quality thermal insulation is achieved with less and less consumption of energy for heating. Fireplace usually has a sufficiently large heat capacity, which at the time of heating relatively quickly heats the air in the room in which it is installed. In some cases, therefore, is used part of energy from a fireplace to heat the hot water for heating other rooms. These systems require a relatively large water storage tanks with complex regulatory elements.

The problem remains uneven temperatures in the large space rooms, in which is usually installed fireplace. Around the fireplace is a part of the room overheated and more distant parts of the room are, however, poorly heated. If the room has large window surfaces and more fragmented area e.g. with bay windows, this problem is even greater. More distant parts of the room also cool faster after heating interruption, e.g. during the night.

The solution of these problems can be AKU heating system, which allows the distribution of hot air from the fireplace into the floor, which also serves to accumulate heat uniformly throughout the room. Simultaneously it reduces the overheating of the room during the heating operation in the fireplace and then maintains the desired temperature in the space for a longer time.

This article is a continuation of publication (Kic, 2013), in which has been described the basic principles of the underfloor AKU heating system and the results of measurements in experimental laboratory conditions. The aim of this paper is to present some results from measurements and experience from the implementation of AKU heating system in the construction of a real family house.

MATERIALS AND METHODS

This research work and measurements of the actual values were carried out in the new construction of low-energy consumption house in the Czech Republic. This is a classic two-storeyed building constructed from thermo-insulating brick blocks, with a flat roof and a built-in garage. All the technological equipment is concentrated in the technical room on the ground floor as well.

As an unattended heating source has been selected heat pump air-water with warm water underfloor heating by pipelines inside the concrete accumulative layer. Ventilation of house is provided by recuperation unit. Air ducts are combined with the hot air distribution for heating from the fireplace and AKU floor air distribution system. This heating system that takes energy from irregular sources of heat-cold (fire, sun, cooling) should distribute the heat more uniformly in space but also in time. After the initiation of heating in the fireplace and distribution of hot air into the floor, temperature sensor of water floor heaters reacts and shut down the heating. After cooling of the floor is water floor heating from heat pump switched on again. So the inhabitant can not recognise that something happened and has permanently pleasant warm floor.

Measurements were focused on the verification of the function of AKU floor heating from the fireplace installed in the living room located on the ground floor area of 30 m^2. The cold air is sucked by fan with an average air flow of 450 $m^3\ h^{-1}$ into the air duct, by which the heated and warm air flows into the distribution system formed by distribution AKU elements in the concrete floor of a thickness 60 mm which ensures the heat accumulation. There the thermal energy is transmitted to the storage layer and the cooled air flows back into the room.

The measurement process was divided into two parts. The first part started by burning of wood in the fireplace and by the operation of AKU system and hot air distribution in the floor. The wood has been burned approximately 4.5 hours. In the second part of the measurement was a fireplace left without supply of wood and after another 2 hours burning completely finished. Basic measurements still continued for 1.5 hours, a total of 8 hours from the beginning of measurement.

Air temperatures were measured by thermocouples NiCr-Ni type K during the air flow through the whole system (in the inlet, after the heating, also in different parts of distribution systems of under-floor heating, and in the outlet from the pipeline at the end of the heating system.

Furthermore, there was measured by thermocouples the temperature at the bottom of the concrete layer (between distribution element and the concrete). Under the concrete layer was measured the heat flux passing into the accumulation mass of the floor by the heat flow plates type FQA 017C and there was measured also the heat flux on the surface transferred from the floor surface to the air by the heat flow plates type FQA 018C. The temperature of the upper surface of the concrete was measured by thermographic camera IR Flexcam Pro.

Thermal comfort in the space heated by radiant heating is necessary to evaluate by globe temperature (measured by globe thermometer FPA 805 GTS) together with air temperature. All data were measured continuously and stored at intervals of three minutes to measuring instrument ALMEMO 2590-9.

RESULTS AND DISCUSSION

Principal results of microclimate measurement and description of the AKU system function is presented in the Figs 1–5. Curves of temperatures in the Fig. 1 show gradual heating of the air and floor during the heating and cooling of the fireplace. The curves on the graph confirm significant effect of radiant heating component, which is reflected by higher globe bulb temperature (tg) than the air temperature (ta). Approximately 4.5 hours after the heating (after wood burning) has a significant effect heat accumulated in the floor and slowly transferred into the room, which results in the higher surface temperature (ts) than the air temperature (ta). The maximal surface temperature was 22.1 °C, which is below the 30 °C recommended as a maximum for floor surface temperature in literature (Cihelka, 1961).

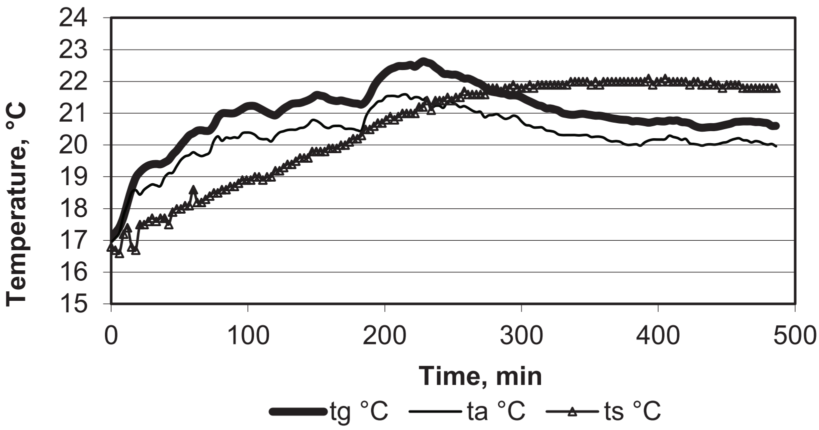

Figure 1. The course of air temperature (ta), globe temperature (tg) and surface temperature on the floor (ts).

The heating of the whole floor in the living room is gradual. It corresponds with the surface temperature measured by thermographic camera (Figs 2–4). In the first hours most rapidly warmed the floor surface near the fireplace mainly by radiation from the front surface fireplace (Fig. 2). It is obvious from the floor surface on the thermogram (Fig. 3) in the front of the fireplace after 6.5 hours since the beginning of heating (fire is completely burnt out) that the surface temperatures of the floor in different parts of the room are already balanced.

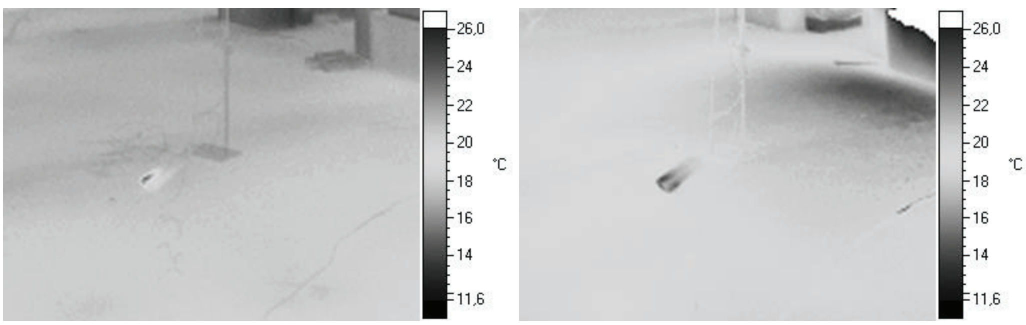

Figure 2. The thermogram of the floor surface near to the fireplace at the beginning of heating period and after 2 hours of heating.

Fig. 4 shows us thermogram of the floor surface in front of the fireplace after 8 hours from the beginning of heating; the floor still maintains a higher temperature than the air in the entire area equally thoroughly heated. There is the heat flux transferred into the concrete accumulation layer and from the surface by radiation and convection into the room. The result should is comfortable, rather stable temperature distributed uniformly in space during the longer time.

Even more apparent is the effect of heating by the floor AKU system from the course of the specific heat flow on the floor surface specific heat flux on the surface from the concrete floor to the air inside the room presented on the Fig. 5.

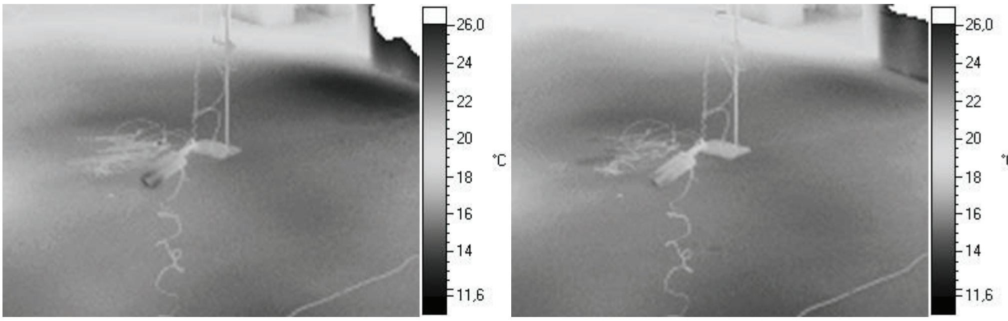

Figure 3. The thermogram of the floor surface after 4.5 hours of heating (there is finished wood stoking in the fireplace) and after 6.5 hours since the beginning of heating (fire is completely burnt out).

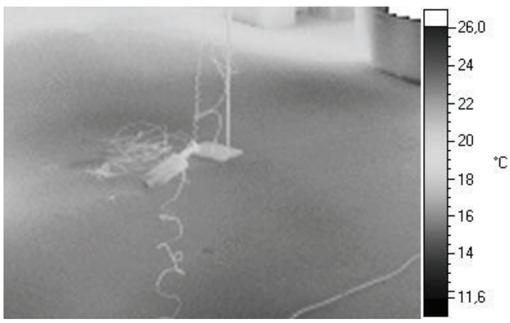

Figure 4. The thermogram of the floor surface after 8 hours since the beginning of heating. The floor still maintains a higher temperature than the air.

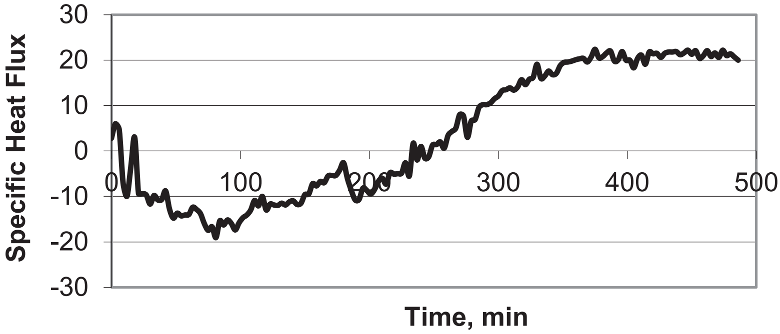

Figure 5. The specific heat flux (W m^{-2}) from the floor surface to the air.

The first 250 minutes is negative heat flux on the floor surface, which means that the massive concrete floor is gradually heated by hot air circulation inside floor as well as by shared heat from the warm air in the room near the fireplace. After 250 minutes, there is a progressive increase in a positive heat flow from the floor to the room. The accumulated heat keeps the whole floor surface for several hours warm after the end of fuel supply.

CONCLUSIONS

The results of measurements in the living room showed that the radiant heating with accumulation of energy in the floor compensates temperature differences. The accumulation of excessive heat into the floor with accumulation capacity enables the reduction of overheating during the heating period and subsequently the longer maintaining of required temperature inside the room.

Radiant component of heat transfer very favourably influences the thermal comfort of indoor environment. The heat can be intensively distributed around the house with time shift. The result is the more stable thermal comfort inside the room and savings of heating costs. This system is particularly suited for rural areas, as it is possible to use wood or other biofuels for heating. As there are not visible radiators inside the room, it is reduced the risk of injury and it allows achieving easily an aesthetically impressive interior room. It is suitable for new or modernized rural family houses.

ACKNOWLEDGEMENTS. Author is grateful and express many thanks to the company Atelier Zilvar and Mr. Lipka who permitted and enabled to author to carry out all measurements of indoor environment in room equipped by the AKU heating system.

REFERENCES

Cihelka, J. 1961. *Radiant Heating*. SNTL, Praha, 373 pp. (in Czech).

Kic, P. 2013. Hot-Air Heating of Family Houses with Accumulation of Energy in the Floor. *Agronomy Research* **11**(2), 329–334.

Kic, P. & Kadlecek, B. 2012. Improvement of heat balance of family house. In Galins, A.: *12th International Scientific Conference Engineering for Rural Development*. Latvia University of Agriculture, Jelgava, Latvia, pp. 134–138.

Papez, J. & Kic, P. 2013. Wood moisture of rural timber constructions. *Agronomy Research* **11**(2), 505–512.

Vio, M. 2011. *Climatization with Radiant Systems.* Editoriale Delfino, Milano, 264 pp. (in Italian).