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MICROCLIMATE IN ROOMS HEATED BY TILED FIREPLACE WITH THE FUNCTION OF ACCUMULATION OF HEAT

Abstract

The article presents the analysis of microclimate in rooms equipped with tiled fireplace with the function of accumulation of heat. Two research series, conducted in used premises, were presented.

Keywords: Building physics, ventilation, indoor air quality, heating by tiled fireplace

1. Introduction

One of the most important problems of modern structure engineering is not the isolating users from the external environment, but reaching and keeping the parameters of internal air. The parameters of internal air describe the microclimate in buildings. When these parameters are on the adequate level, we can talk about thermal comfort. Lots of thermal comfort parameters cannot be measured. The research conducted for many years, were supposed to find a link between the subjective feelings of users and the parameters describing interior microclimate. This studies led to determine five group of factors [1-7]:

1. The thermal comfort – the inside temperature, the temperature of surrounding surfaces, the air humidity, the air velocity, the insulation of clothing, the people activity, and the like.
2. The air quality (cleanliness of air) – harmful or troublesome substances, the solution of ventilation system, the exchange of air in building, and the like.
3. The lighting – the daylight, the intensity and the color of artificial light, and the like.
4. The noise – the attenuation of external or internal partitions.
5. Other factors: the factors associated with sense of smell, the visual factors, and the like.

The authors have focused their attention on the microclimate parameters, which are classified

as thermal comfort parameters and air quality parameters. There was the untypical heating system in the analyzed building. As the main source of heat, the tiled fireplace with the function of accumulation of heat, was used (in contrast to traditional, water heating used in Poland).

2. Subject and methods of the study

The research were carried out in premises situated on the ground floor of two-storey building. However, it should be noted, that they constituted a separate entity (with separate entrance from the outside) equipped with the individual heating system. The traditional brick building built in the middle of sixties of the last century was analyzed. In 2011 year, the three-layer external walls were additionally insulated with layer of the polystyrene and the new facade was made. The building was equipped with gravitational ventilation.

The total area of the analyzed premises is about 80 m². Their function is a showroom and dealership. They are used in the hours of 7 am to 5 pm.

In order to determine conditions in the room, the following microclimate parameters were measured: air temperature, relative humidity and carbon dioxide concentration (which was the indicator of the air quality). In addition, the flow rate in gravitational ducts and the variations of direction of air flow, were being recorded. Two cycles of measuring were carried

out. Each of them lasted 14 days. The first cycle was carried out in the autumn, the second in the winter. The interval of recording the measured parameters was set for 5 minutes.

The main source of heat was the tiled fireplace with the function of accumulation of heat mounted in 2013 year. The additional source of heat was a two-function gas boiler. This source was turning on only in case of very low external temperatures and it powered the traditional plate heaters of steel, which were mounted on the external walls. During the analysis, the gas boiler was turned off.



Fig. 1. The tiled fireplace – the appearance and the diagram of operation [8]

The main source of heat was the tiled fireplace, which combines the features of the traditional fireplaces and stoves used for heating premises. The difference is in the used modern materials. The any contribution of steel or iron may constitute the furnace connected with the accumulative heat exchanger, provided that the stream of external air, necessary to burn, will be delivered. The accumulating ducts are made of the modern, heavy fireclay or the thermal mass of fireproof concrete). The right amount of air flowing into the furnace ensures an optimum and complete combustion of wood and proper heating of accumulation material. The exhaust gas are flowing out from the furnace at high temperature, which equals 600-1000°C. This parameter is reduced to 100-200°C in the mouth of the chimney, what means high efficiency of this solution.

3. Results

In all premises of the analyzed service premises the variation of the microclimate parameters was similar. The values of the measured parameters (CO₂ concentration, indoor temperature, humidity of air)

were increasing since turn on and start usage of the tiled fireplace. In a short time parameters reached maximum values (Fig. 2). The values of some parameters were falling down, when users of premises have left building. In night's hours, the parameters have reached high values again.

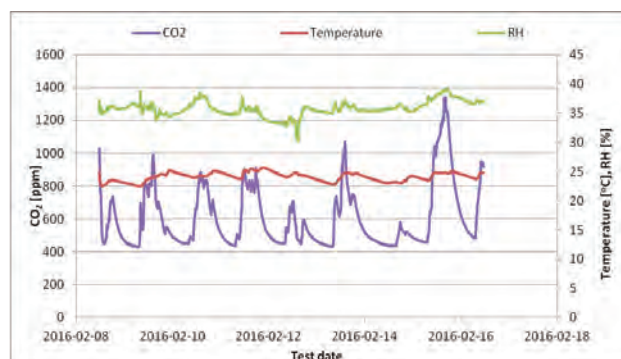


Fig. 2. The weekly variability of the microclimate parameters

The relative humidity and the carbon dioxide concentration decreased when the employees had left the premises (Fig. 3). This decrease was slow but immediate. In turn the temperature usually continues to rise (Fig. 3). A further increase the indoor temperature was resulted from the heat accumulation in the tiled fireplace. This source still has been heating the premises after firing the wood. After a few hours the internal temperature started to fall down, until the tiled fireplace was burning again. It should be noted, that decreasing of air humidity was not continuous. The air humidity stabilized, and then increased slightly, before start of work in the object and before people appearance in building.

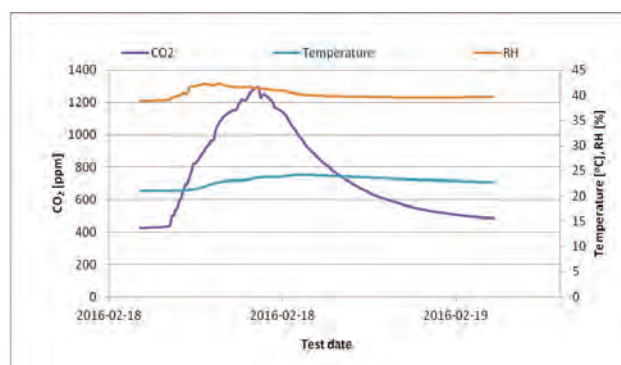


Fig. 3. The daily variability of the microclimate parameters in the analyzed premises

It should be noted that the values of the measured parameters depended on the location of the measuring device in relation to the tiled fireplace location. The

fireplace was located in the central part of premises, which allows for heating all the room, at the analyzed building. The measuring devices were located at the workplace, closest to the fireplace (approx. 2.5 m) and near the front door (approx. 7 m). The values of average temperatures measured on the measuring position No. 1 differed from the values measured on the measuring position No. 2 only by 0.4°C. The difference in the average values of the relative humidity equaled to 1% and the difference in the average values of CO₂ concentration equaled to almost 200 ppm. The differences in the relative humidity and in the CO₂ concentration were so small that they were undetectable by users. However, people, who were occupying space at a greater distance from the heat source were complaining of low temperature just after the start of work. While people, whose jobs were near to tiled fireplace, reported that temperature is too high already approx. 2-3 hours after the start of heating. These feelings have a close relationship with the minimum and maximum temperatures recorded on two measuring positions (Table 1).

Table 1. The parameter values recorded in the 1 and 2 measuring stations

Parameter	Position No. 1			Position No. 2		
	Min.	Max.	Average	Min.	Max.	Average
Temperature [°C]	19.9	25.4	23.0	18.5	23.1	22.6
RH [%]	32.1	45.5	38.0	30.3	46.6	37.0
CO ₂ [ppm]	423	1342	641	409	1029	467

During weekends variability of microclimate parameters also have an established pattern. Since the moment of complete consumption of fuel, the temperature has been dropping until Monday morning. Then a fireplace was again lighted. The lowest recorded temperature on Monday morning did not differ significantly from the temperatures recorded in other days morning (before starting the heating). It equaled 19.1°C. When the air temperature was dropping, the relative humidity of air was increasing. The maximum recorded value of humidity on Monday morning reached 50%, and values recorded on another weekdays did not exceed 45%. The values of CO₂ concentration measured in the morning were the lowest during the day, and regardless of what day of the week it reached the similar values to the parameter concentration in the outside air.

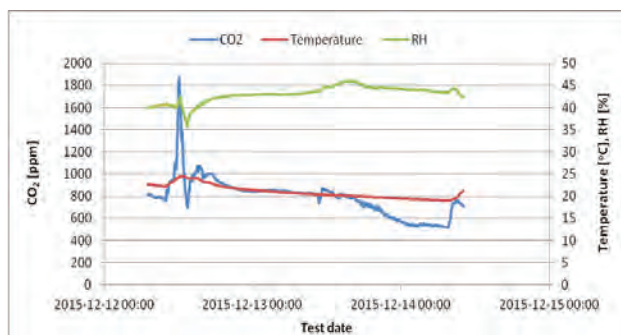


Fig. 4. The variation of microclimate parameters during the weekend

4. Conclusions

The analysis of the obtained data of microclimate parameters, especially daily variability of indoor temperature, showed that heating by tiled fireplace with the function of accumulation of heat is not good solution. However, due to the burning of biofuels, it is in line with the current trend of sustainable construction. To ensure the thermal comfort of people staying in premises which are heated in analyzed manner, the great drop of inside temperature, at night hours have to be eliminated. The negative effect is possible to eliminate, by using the fuel feeder (timber) into the combustion chamber. In this way the combustion is continuous and the temperature is constant all day. This means, that the problem with the parts of premises which are not enough heated (located at greater distance from the fireplace) is eliminated. Another solution is using additional heat source, for example a gas boiler and the water central heating which is traditionally used in Poland.

The recorded values of air humidity were in range of the recommended values. Also, the authors did not raise an objections to the CO₂ concentration values. The values exceeding 1200 ppm were recorded exceptionally, and they were temporary. The rapid decline of the parameter value was observed after leaving the premises by employees. The average CO₂ concentration of external air equaled 419 ppm. The recorded average values of parameters in premises let to classify the buildings to the average category of indoor air quality (IDA 2) according to [9]. Taking into account the maximum recorded values of CO₂ concentration in the analyzed premises, they should be classified in the category of the moderate indoor air quality (IDA 3). The classification in the such a high category is possible because of the proper air flow into the combustion chamber, the high sealing the building and the ensuring correct air exchange because of window vents.

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Mikroklimat w pomieszczeniach ogrzewanych piecem kominkowym z funkcją akumulacji ciepła

1. Wstęp

Jednym z najważniejszych problemów współczesnego budownictwa nie jest fakt odizolowania użytkowników od warunków zewnętrznych, ale w jaki sposób ukształtować i utrzymać pożądane przez nich warunki wewnętrzne.

W trakcie badań opisanych w tym artykule uwagę skupiono nad parametrami mikroklimatu zaliczanymi do komfortu cieplnego oraz jakości powietrza. W rozpatrywanym obiekcie nietypowy był system ogrzewania. Jako główne źródło ciepła wykorzystany został piec kominkowy z możliwością akumulacji ciepła.

2. Przedmiot i zakres badań

Budynek w którym prowadzono badania wykonany został w połowie lat sześćdziesiątych ubiegłego wieku w technologii murowanej. Trójwarstwowe ściany zewnętrzne w roku 2011 zostały dodatkowo zaizolowane od zewnątrz warstwą styropianu z wyprawą elewacyjną. Obiekt posiada wentylację grawitacyjną. Pomieszczenia, w których realizowano badania mają łączną powierzchnię ok. 80 m². Badania obejmowały rejestrację przebiegu zmian temperatury, wilgotności

względnej oraz stężenia CO₂. Zrealizowano dwa cykle pomiarowe, z których każdy trwał 14 dni.

Głównym źródłem ciepła był piec kominkowy z możliwością akumulacji ciepła. Dodatkowe źródło ciepła stanowił dwufunkcyjny kocioł gazowy uruchamiany jedynie w przypadku bardzo niskich temperatur zewnętrznych.

3. Wyniki badań

We wszystkich pomieszczeniach analizowanego obiektu przebieg zmienności parametrów mikroklimatu odbywał się według tego samego schematu. Wartości mierzonych parametrów wzrastały od momentu rozpoczęcia użytkowania oraz uruchomienia pieca kominkowego. W krótkim czasie osiągały one wartości maksymalne. Po opuszczeniu pomieszczeń przez użytkowników wartości poszczególnych parametrów spadały, aby w okresie nocy przyjąć ponownie wartości wyjściowe.

Wyznaczono dwa stanowiska pomiarowe oddalone o 2,5 m oraz 7 m od źródła ciepła. Wartości średnie temperatury odnotowane na stanowisku pomiarowym nr 1 różniły się od wartości na stanowisku nr 2 zaledwie o 0,4°C. Różnica wartości średnich wilgotności względnej wynosiła 1%, a stężenia CO₂ prawie

200 ppm. W zależności od odległości od źródła ciepła użytkownicy uskarżali się na przegrzanie lub niedogrzenie pomieszczeń.

4. Podsumowanie

Analizując otrzymane wartości parametrów mikroklimatu należy stwierdzić, że ogrzewanie piecem kominkowym z możliwością akumulacji ciepła nie jest najkorzystniejszym sposobem ogrzewania pomieszczeń. Dla zapewnienia komfortu cieplnego ludzi przebywających w pomieszczeniach ogrzewanych w ten sposób niezbędne byłoby wyeliminowanie znacznych spadków temperatury wewnętrznej w okresie nocy. Jest to możliwe poprzez zastosowanie podajnika paliwa (drewna) do komory spalania lub zastosowanie dodatkowego źródła ciepła.