environment

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ADDITIONAL AIR INTAKES AS THE ELEMENT SUPPORTING NATURAL VENTILATION

Abstract

Enlargement of the thermal isolation of external barriers is the simplest and the most effective way to reduce the waste energy on the heating aims. Unfortunately, inappropriate analysis and luck of coordination while performing thermomodernizational work, negatively influences the microclimate in such objects. The size and the distribution of the intake openings has been decisive for proper functioning of gravitational ventilation and warranty for the proper parameters of internal microclimate. Even small works done on thermomodernizational ventilation may influence the quality of work of the whole system of gravitational ventilation. These work should be carefully designed, planned and carried out efficiently.

Keywords: natural ventilation, air intakes

1. Introduction

The growth of maintenance costs of objects and taking care of natural environment have led to searching and promoting solutions reducing the waste of energy on the heating aims of objects. Enlargement of the thermal isolation of external barriers is the simplest and the most effective solution as far as this problem is concerned. Unfortunately, inappropriate analysis and not coordinated thermomodernizational work has negative influence on the microclimate in interiors of such objects. This article presents the problems met while leading research concerning microclimatic conditions in buildings where thermo - modernization was used. Polish standards related to microclimatic conditions, ventilation of buildings and air exchange were contained in three legal acts. In the decree [1] in the matter of technical conditions which the buildings and their location should obey the general requirements concerning ventilation were presented. Moreover, detailed requirements related to individual solutions of the ventilation systems were presented in valid for about twenty years norm [2] and its supplement [3]. This norm says, that windows of the infiltration coefficient smaller than 0.3 $m^3/(mhdaPa^{2/3})$ mounted in habitable buildings of public usefulness should be equipped with the air intakes providing the right quantity of air necessary for ventilation. In case of the lack of such an air intakes, mechanical supply ventilation has to be installed in the rooms. In all other cases, the coefficient of infiltration of woodwork has to be comprised in borders 0,5-1,0 m^3 $(mhdaPa^{2/3})$. The above mentioned requirements were settled for all buildings regardless of their height, tightness of barriers or location. These regulations are used not only in case of newly built buildings, but also with reference to objects where thermo - modernization was used. These workings are very complex as they concern the works from several fields of building engineering. Unfortunately, according to valid regulations [4], some thermomodernizational works can be conducted by the users of objects without earlier coordination or permission. This has an impact on/influences/ the quality of internal microclimate and air exchange.

2. Carbon dioxide as the indicator of air quality

The relationship between the quantity of ventilating air and the concentration of carbon dioxide inside the rooms is recognized and an applied criterion for air quality valuation. The frequent occurrence of carbon dioxide in typical conditions is not dangerous. This non – toxic gas can only cause the habitants the feeling of smaller or larger discomfort, i.e. air stuffiness. In closed rooms one usually observes the growth of carbon dioxide concentration in the air coming from external and internal sources. First of all, it penetrates to the room from the outside by means of air infiltration through untightness in the lining of the building. The growing degree of industrialization causes the growth of the level of carbon dioxide concentration in the atmosphere. At present its value is between

400 – 600 ppm. Living organisms and gas devices are the source of carbon dioxide inside the rooms. Its concentration depends on organism activity and may vary for individual people depending on their diet, the body mass and the degree of fitness. Obviously, the concentration of carbon dioxide depends on the number of people inside the room, not sufficient air exchange (the decrease of oxygen concentration in the air) and intensification of combustion processes in the room (e.g.: smoking tobacco, preparing the meals). That's why carbon dioxide was chosen as the measure of microclimate quality inside considered flats.

According to Hodgson [5], the critical value of carbon dioxide concentration is 8500 ppm. The present standards for the internal air assume the admissible level of carbon dioxide concentration is on the level of 1000 ppm. This coefficient was proposed by Max von Pettenkofer in the nineteenth century [6].

Table 1. Emission of carbon dioxide for different levels of activity [7]

A type of activity	Emission of carbon dioxide [dm^3/h]
Dream (motionless recumbent position)	10 - 12
Sitting position (without doing any work)	12 - 15
Sitting posture – easy office works	18 - 25
Doing work of average difficulty	32 - 44
Doing hard work	> 55

Table 2. The influence of carbon dioxide on human organisms [8]

No.	Concentration of carbon dioxide in the air [ppm]	The symptoms
1.	300 - 450	Dry external air
2.	1000	Basis for the qualification of most standards concerning the quantity of ventilating air for a single person
3.	1550 - 500	The growing feeling of stuffiness
4.	5000	Limitations concerning working posts
5.	7000 - 10000	The growth of breathing capacity
6.	15000	The appearance of metabolical stress
7.	20000	The increased frequency of breathing and headaches
8.	40000 - 52000	Carbon dioxide concentration in the air breathing out from the lungs
9.	60000 - 80000	The possibility of partial paralysis
10.	>80000	Losing of consciousness in a few minutes

3. The object of researches

The researches were conducted in a five – storied habitable building built with traditional technology. Ventilation was designed and executed as gravitational with the system of cumulative ducts. Inside the flats there were installed gas ranges and the heaters of warm water with open combustion chamber powered with the earth gas from the grid. The buildings had external walls warmed with foamed polystyrene covered with thin – layered mineral plaster. Additionally, the users of particular flats exchanged the old window woodwork for the new one, which the infiltration coefficient spanned 0.30 – 0.45 m3/mhdaPa$^{2/3}$ (according to producer's data, depending on the flat). The object of researches were typical parameters of internal microclimate. That is, the temperature, relative humidity and concentration of the dioxide inside considered flats. Moreover, temporary speeds of the air flow and the direction of the flow of stream of air were measured through the entire period of investigation.

4. The results of measurements

During the researches there have been observed considerable disorders in performance of the system of gravitational ventilation. They mostly relied on the appearance of backward ducts in ventilating ducts. It was a principle in the considered building, that one of the ducts in the grounds of the given flat took over the part of the element delivering external air. Observed speeds near the given inlets of ventilating ducts oscillated between 0.00 m/s and 1.35 m/s for ducts removing the air. However, in case of ducts where intake ventilation took place they oscillated between 0,00 m/s and 1.44 m/s (Fig. 1). The above situation was inconvenient, because when the temperature reached approximately -10^{O}C, the temperature of the intake air near the grate outlet equaled about +15^{O}C (Fig. 2). In rooms in which there were air grates and air ventilation, the temperature inside the room equaled about +17 – +19^{O}C with turned on heating. Characteristic phenomenon was the alternating character of the direction of ventilating air in particular ducts in the examined flat (Fig. 1). If the duct in the kitchen removed the air from the flat, the bathroom duct supplied external air. However, if the external air was forced in through the kitchen duct, the bathroom duct removed the internal air. Ventilation took place mostly through the duct in the room where gas devices were installed. Only in the situation when at least one casement was opened, both ducts were removing the air from the rooms. This phenomenon indicated that too tight building casing unabled suitably right infiltration of external air. Thus, one of the ventilating ducts takes over the part of the element delivering external air, which is necessary for the needs of gas combustion and living conditions.

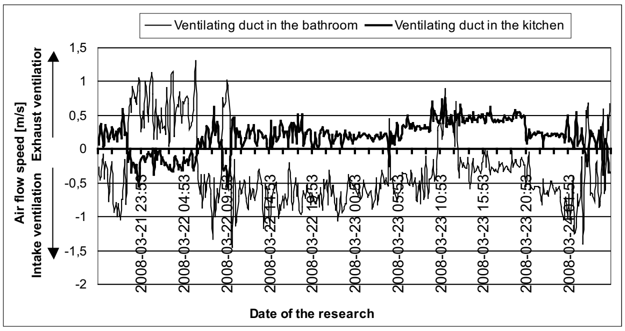

Fig. 1. The course of changeability of the direction and the speed of the stream flow of ventilating air through particular ventilation ducts

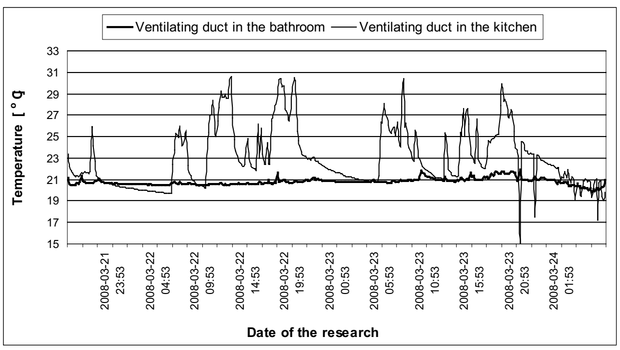

Fig. 2. The diagram of changes of the temperature near the inlets of ventilating ducts

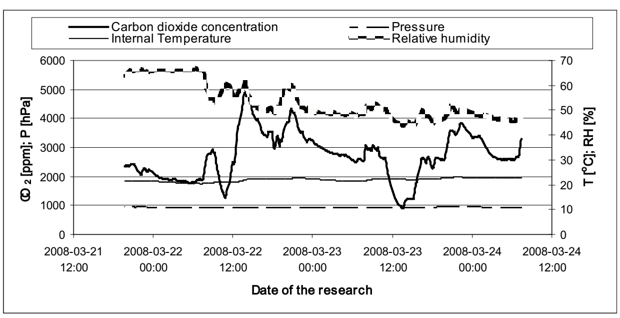

Fig. 3. The diagram of the parameters of microclimate in a chosen flat with the air inflow through the ventilating duct

The phenomenon described above influenced the level of the microclimate inside considered rooms. Carbon dioxide concentration oscillated between 2500-4000 ppm and its maximum valued equaled 5000 ppm. The concentration of carbon dioxide only fell below 2000 when the casements were opened. These values are at least twice higher compared to recommended norms. The parameter of relative humidity also achieved high values, as they oscillated between 44-68%. The diagram of internal microclimate parameters for one of the considered flats is presented in Fig. 3.

Additional air intake ventilators were installed in Additional air intake ventilators were installed in window woodwork, so as to improve internal microclimatic conditions. However, the users of flats began to complain because of too large speeds of the flow of air (causing the dry air) and cooling the rooms. Alternatively, it was proposed to bring the external air necessary for gas combustion in gas devices. This was done due to additional ducts in diameter 100 mm, bringing the air near gas stoves and heaters of warm water. The ducts were led through unused rooms, due to the fact, that the air was heated initially.

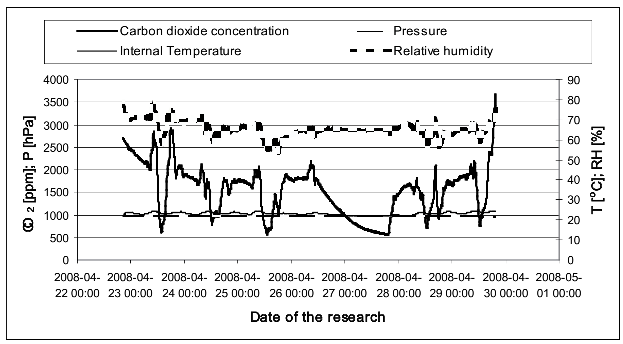

Fig. 4. The diagram of the parameters of microclimate in a chosen flat with additional intake ventilation openings

As a result of such conditions there appeared some disorders in the performance of the system of gravitational ventilation. The phenomenon of the occurrence of backward ducts in ventilating ducts and parameters describing internal microclimate accepted more reasonable values. Carbon dioxide concentration did not exceed the level 3500 ppm and the relative humidity oscillated around the value 50%. The diagram of the changeability of parameters in the flat with additional duct is presented in Fig. 4.

5. Analysis of the results. Conclusions.

The irregularities described above are the result of the limited inflow of external air to flats. That is necessary for the proper working of the ventilation system and for the proper course of the process of gas combustion in heating devices. This limitation is the consequence of the "improvements", what limited natural infiltration of external air. All conducted works resulted in liquidation of existing paths of the inflow of external air to flats. This in turn disturbed the working of gravitational ventilation. In case of flats in which windows were not exchanged, the inflow of external air was too small. It was caused by of the lack of tightness, what caused backward ducts. Additionally, gas heating devices disturb the working of ventilation in a particular building. As a result of installing feedwater heaters with the open combustion chamber, there appeared a sudden growth of carbon dioxide concentration, with simultaneous turning back of the duct in ventilating duct. Use of the additional openings in external barriers (intake ventilators) increases the right quantity of external air. According to flat users these devices influence negatively the comfort of the use of flats. The increase of the flow of external air because of window untightness influences only an air exchange to a limited degree. Thus for the occupants it is necessary to use this function wisely. As far as window untightness is concerned, it is not possible to regulate the air stream of inflowing air. The quantity of inflowing air does not depend on internal air parameters. Additionally, quick cooling of the rooms that follows during the winter period is arduous for the flat users. Using the openings supplying the air to flats through unused rooms, significantly improved parameters of internal microclimate. However, microbiological analysis of the air is required.

To sum up the above mentioned observations it should be noticed that:

1. Disorders of microclimatic conditions in flats with tight casing and heating gas devices result in backward ducts and decrease of air exchange. However, it particularly relates to two last storeys.
2. The size and the distribution of intake openings has a decisive meaning for the proper working of gravitational ventilation and the assurances of proper parameters of internal microclimate. Each decision about the size and distribution of intake openings should be preceded with the analysis of: localizational conditions of the flat, construction al possibilities, the demand of the air (balance). The preliminary warming of ventilating air limits disorders of internal microclimate conditions.
3. Conducting thermomodernizational works, even in a small range, may influence the quality of the working of gravitational ventilation. These works should be projected and done efficiently.
4. It is possible to attain the proper working of the system of gravitational ventilation in thermo- modernized buildings under the condition of co-ordination of planned works.
5. In case of the arrangement of thermomodernizational works on several necessary years, it is necessary to settle their order, so as not to disturb the system of natural ventilation.

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Marek Telejko

Dodatkowe otwory nawiewne wspomagające wentylację naturalną

1. Wstęp

Wymagania norm krajowych.

W ciągu ostatnich 20 lat wzrosło zainteresowanie budownictwem energooszczędnym. Niestety zarówno wykonawcy, projektanci jak i przyszli użytkownicy zbyt mało uwagi poświęcają zagadnieniom wymiany powietrza, jako przedsięwzięciom drogim, nierentownym lub w ich opinii nieistotnym.

Krajowe akty prawne [3], [4], wskazują, iż okna o współczynniku a ≤ 0.3 $m^3/(mhdaPa^{2/3})$ montowane w budynkach mieszkalnych powinny być wyposażone w nawiewniki powietrza. Współczynnik ten ustalono dla różnicy ciśnień wynoszącej 10 Pa, bez względu na wielkość budynku czy jego usytuowanie. Analizując wymagania dotyczące szczelności stolarki okiennej w innych krajach należy stwierdzić, iż w większości z nich poza różnicą ciśnień określona jest wysokości budynku, jego szczelność lub usytuowanie. Dane te wskazują jednoznacznie, że wymagania Polskie należą do najostrzejszych.

2. Dwutlenek węgla wskaźnikiem jakości powietrza

Stężenie dwutlenku węgla wewnątrz pomieszczeń jest uznawanym i powszechnie stosowanym kryterium oceny jakości powietrza [1], [2]. Obecne standardy dla powietrza wewnętrznego zakładają dopuszczalny poziom stężenia CO_2 na poziomie 1000 ppm [1].

3. Przedmiot badań

Badania prowadzono w budynkach mieszkalnych, 3-4 kondygnacyjnych, wielorodzinnych wykonanych w technologii tradycyjnej, wybudowanych w latach 2000-2003. Obiekty wyposażone był w kanałowy system wentylacji naturalnej, kuchenki gazowe oraz piece dwufunkcyjne z otwartą komorą spalania, posiadały szczelną stolarkę okienną wyposażoną w nawiewniki oraz ściany zewnętrzne ocieplone styropianem.

4. Wyniki pomiarów

W trakcie pomiarów zanotowano bardzo duże zaburzenia w działaniu wentylacji grawitacyjnej. W kanałach wentylacyjnych zanotowano wsteczne ciągi co w chłodne dni powodowało wyziębianie pomieszczeń. W trakcie korzystania z urządzeń gazowych odnotowano bardzo szybki wzrost stężenia CO_2. Charakterystycznym zjawiskiem był przemienny charakter przepływu strumienia powietrza wentylacyjnego w kanałach wywiewnych.

Dla poprawy mikroklimatu w mieszkaniach zaproponowano wykonanie dodatkowych otworów ϕ120 mm w ścianach zewnętrznych, a na wylotach kanałów wentylacyjnych zainstalowano urządzenia typu aspiromatic. Prace te doprowadziły do prawidłowego kierunku przepływu we wszystkich kanałach, ale jednocześnie odnotowano nadmierne wychładzanie mieszkań oraz zbyt duże prędkości przepływu.

Z uwagi na komfort użytkowników, przywrócono stan poprzedni jednocześnie wykonując otwory doprowadzające powietrze wentylacyjne w ścianach wewnętrznych na klatkę schodową i zlokalizowanych z bezpośrednim sąsiedztwie pieców gazowych. Wykres parametrów mikroklimatu w jednym z mieszkań gdzie zastosowano powyższe rozwiązania przedstawia rys. 4.

5. Analiza wyników

Zaobserwowane nieprawidłowości są wynikiem ograniczonego napływu powietrza zewnętrznego.

Zastosowanie otworów doprowadzających powietrze do mieszkań pośrednio poprzez klatkę schodową dla spalania gazu w piecach dwufunkcyjnych poprawiło parametry mikroklimatu wewnętrznego, ale wymagana jest analiza mikrobiologiczna powietrza.

6. Wnioski

1. Zaburzenia warunków mikroklimatycznych w mieszkaniach ze szczelną obudową i gazowymi urządzeniami grzewczymi przejawiają się występowaniem wstecznych ciągów oraz zmniejszeniem wymiany powietrza i dotyczą szczególnie dwóch ostatnich kondygnacjach.
2. Pojawienie się urządzenia grzewczego w mieszkaniu powinno być uzależnione od wykonania osobnego kanału, odpowiednio obudowanego,

doprowadzającego powietrze do urządzenia lub zastosowania zamkniętej komory spalania.

3. Wielkość otworów nawiewnych i ich rozmieszczenie ma decydujące znaczenie dla prawidłowego działania wentylacji grawitacyjnej oraz zapewnienia właściwych parametrów mikroklimatu wewnętrznego.
4. Decyzja o wielkości i rozmieszczeniu otworów nawiewnych powinna być poprzedzona szczegółową analizą: warunków lokalizacyjnych mieszkania, możliwości konstrukcyjnych, zapotrzebowaniem powietrza (bilans).