ISSN 2229-5518

Possibility of evaluation of insulation and accumulating ability of the room on the data of the transition process after turning off the heat

Rumen Yankov, Mariyana Ivanova, Veselina Dimitrova, Ventsislav Dimitrov

Abstract— This article explains an approximate way of calculating the building thermal insulation coefficient **(D)** and accumulation ability **(B)**, using the equation for heat balance for the transition process after the turn off (shutdown) of the heat supply. The method is based on the experimental detection of room temperature, variations during the shutdown off the heat supply in the room.

Values obtained by this method **(D)** and **(B)** are approximate and allow an estimate of the room thermostability (building) not represented here.

Index Terms— Energy efficiency of buildings, Thermal insulation capability, Heat accumulating capacity, Thermal stability

1 Introduction

The energy efficiency of buildings is assessed by the insulation ability of the fencing elements of the rooms (external walls, windows, doors, ceilings, floors, intermediate walls, etc.) and the dampening of the temperature amplitude in the buildings during the time of turn off or reduce the heat supply. Data for quantitative estimate is obtained by calculation, experimental or combined way.

The temperature in the living quarters (**t_{lq}**) is determined according to the sanitary and hygienic norms depending on the function (living rooms, bathrooms, bedrooms, kitchens, children, etc.). During the heating season these temperatures are maintained by supplying the required amount of heat from the respective heating devices (radiators, stoves, air conditioners, etc.). In the same hygienic norms, the allowable temperature deviations **(Δ)** of the set nominal value (**$t_{lq.n.}$**) are recommended. For example, for these premises this deviation is **$\Delta=\pm3°C$**.

As is known, the amount of heat supplied in the room, in the established mode, is equal to heat losses and is maximum when the room temperature is equal to the maximum allowable (**$t_{lq} = t_{lq.n.}+\Delta$**) and the outside temperature is equal to or less than the calculation (**$t_{calc.}$**) for the climatic area where the building is located.

The next one is offered an opportunity to assess the factors for thermal insulation **(D)** and the accumulation **(B)** ability of existing living space, using data on the course of temperature (**t_{lq}**) in it, then turn off the heat supply.

- *Rumen Yankov is Assistant Profesor of Hydraulics and Hydro-Pneumo Machines in Technical University of Sofia, College of Sliven, Sections Road Transport, Textiles and Design Manufacturing, Bulgaria, European Union, e-mail: r.yankov_@abv.bg.*
  His Scientific interests include Hydraulics and Hydro-Pneumo Machines, Theory of Heating and Cooling Technics, Fluid mechanics, Heat and Mass Transfer.

2. Setup the task

2.1. Thermal insulation capability

Thermal insulation capability of the living quarters be assessed by the factor **(D)**, which has the meaning of a general heat transfer coefficient to calculate the total heat losses [1]:

$$Q_3 = (\sum k_i F_i + \sum a_j l_j c_в)(t_{lq} - t_{calc.}) = DF(t_{lq} - t_{calc.}) \qquad (1)$$

The authors offer to losses expressed in terms of dependence:

$$Q_3 = D(t_{lq} - t_{calc.}) \qquad (2)$$

where, after alignment of the right sides, the following occurs:

$$D = (\sum k_i F_i + \sum a_j l_j c_{air})[\tfrac{W}{°C}] \qquad (3)$$

where:

- **$k_i F_i$** - the heat losses through the i-th fencing element (wall, window, door, etc.) to the **$\Delta t = 1°C$**;
- **$a_j l_j c_{air}$** - heat losses from air infiltration through the joints of the windows and external doors;
- **c_{air}**- mass heat capacity of air;
- **F**- the sum of the areas of all the external fencing elements;
- **t_{lq}**- the room temperature;
- **$t_{calc.}$**- calculation value of external temperature.

Given in the reference book for the relevant climatic region.

In equation (1) is not reported heat transfer through intermediate walls to adjacent rooms. There is no such transmission.

2.2. Heat accumulating capacity

Heat accumulating capacity is determined by the amount of heat, which absorb or attach to the fencing elements (walls, roof, floors) when changing their temperature in the interval **($t_{lq.n.}$±Δ)**. In connection with the idea presented by the authors, it is proposed that the accumulation ability is estimated by the amount of heat **Q_a** absorbed or given for **1s**. on the power output of the heat flow:

$$t_0 \pm \Delta = t_{lq} + \Delta - \left(t_{lq} - \Delta\right) = 2\Delta$$

$$Q_{\mathrm{a}} = \sum c_i m_i 2 \frac{\Delta}{\tau_{1,2}} \quad (4)$$

The ratio $\left(\frac{2\Delta}{\tau_{1,2}}\right)$ expresses the assumption that the heating rate of the elements is the same for the entire time interval $\left(\tau_{1,2}\right)$.

where:

- **c_i** and **m_i** are the thermal capacity and the mass of the i-th fencing element. This includes windows, doors, walls, floors,roofs, and other massive objects (bodies) in the room, that have a high thermal capacity **c_i**;

-**t_{fe}** – room temperature of fencing element;

-**$\tau_{1,2}$**-time to lower the temperature with 2Δ℃.

It is assumed that at all points of the fencing element, as well the air in the room, the change of temperature is of the same value and character and is simultaneous.

As soon after turning off the heat, the heat flow supplied by the fencing elements (walls, roof, floor) is equal to the maximum thermal loss, because the maximum value of the temperature difference.

$t_{lq.max} = t_{lq.n.} + \Delta - t_{calc.}$ Applies:

$$Q_{a,max} = \sum c_i m_i \frac{2\Delta}{\tau_{1,2}} = B \frac{2\Delta}{\tau_{1,2}} \quad (5)$$

whence:

$$B = \sum c_i m_i \left[\frac{J}{℃}\right] \quad (6)$$

According to the proposed **B**, it is a constant. Its value is determined by the mass and the heat-physical properties of the building materials used. This is the amount of heat, required to raise the temperature of all fencing elements with **1°C**.

From equality (6) shows that factor **B** has a dimension [J/°C].

2.3. Thermal Stability

Thermal stability of the room is assessed by the ratio (D/B).

3.Solution of the task

The essence of the proposal is based on the following prerequisites:

- at the beginning, when turn on the heat, all the power of thermal sources is used to heat the external walls of the room (to increase their temperature), that is, the supplied heat is totally accumulated. After reaching the maximum room temperature **($t_{lq.max}$=$t_{lq.n.}$+Δ)** the accumulation process ends, the temperature distribution across the walls becomes stationary. The heat supplied is used to compensate for the heat loss of the room. There is an established regime;

- immediately after turning off the heating, the heat losses are compensated by the heat accumulated in the walls. This leads to lower the temperature, respectively, to reduce the temperature in the room. It is assumed that from the moment of turning off the heat the heat balance is:

$$Q_{loss} = -Q_{\mathrm{a}} \quad (7)$$

The process becomes non-established, due to a decrease in the heat content of the walls over time.

-the power of the heat flux, output from the walls **(Q_a)** is given by the factor **(B)** in (5), therefore:

$$\mathrm{D}\left(\mathrm{t_{lq}} - \mathrm{t}_{calc}\right) = \mathrm{B}\frac{2\Delta}{\tau_{1,2}} \quad (8)$$

where:

- Δ - the tolerance of the room temperature **(t_{lq})**. Whence:

$$\mathrm{T} = -\frac{(\mathrm{t_{lq.max}} - \mathrm{t_{calc.}})}{\left(\frac{\mathrm{dt_{lq}}}{\mathrm{d}\tau}\right)_0}, \quad (9)$$

But

$$\mathrm{T} = \frac{\mathrm{BW}\left(1 - \frac{\mathrm{k}}{\alpha_1}\right)}{\mathrm{DF}}, \quad (10)$$

then:

$$\frac{\mathrm{B}}{\mathrm{D}} = -\frac{\mathrm{F}\left(\mathrm{t}_{\mathrm{lq}.max} - \mathrm{t}_{\mathrm{calc}}\right)}{\mathrm{W}\left(1 - \frac{\mathrm{k}}{\alpha_1}\right)\left(\frac{\mathrm{dt}_{\mathrm{lq}}}{\mathrm{d}\tau}\right)_0} \quad (11)$$

where:

- α_1-heat coefficient on the inside of the wall.

$$\frac{B}{D} = \frac{t_{lq} - t_{calc}}{2\Delta}\tau_{1,2}[s] \quad (12)$$

The ratio (B/D), as is known, expresses room thermostability. This is a summary indicator for assessing the energy efficiency of the rooms. Its value is compared with recommended directory data from references books.

The resulting dependence (12) has important practical significance. It enables you to get quick and accurate information from relatively easily measurements in real conditions. For this purpose, the relevant methodology has been developed.

4. Conclusions

This article explains an approximate way of calculating the building thermal insulation coefficient **(D)** and accumulation ability **(B)**, using the equation for heat balance for the transition process after the turn off (shutdown) of the heat supply. The method is based on the experimental detection of room temperature, variations during the shutdown off the heat supply in the room.

Values obtained by this method **(D)** and **(B)** are approximate and allow an estimate of the room thermostability (building) not represented here.

The physical meaning of the relation **(B/D)**, whose dimension is time **[s]** is this: It expresses the time for which the room temperature **(t_{lq})** changes in the boundaries of **($t_{lq.n.}$+Δ)** to **($t_{lq.n.}$-Δ)** provided that the speed of cooling is constant and equal to the home. This parameter is called the time constant of the object. This parameter plays an important role in the choice of the power of thermal sources, frequency of the connections and the economy of the heating system.

References

[1] Иванив,В. „Отопление и вентилация“-Техника,С.1962
[2] Семендяев, „Справочник по математика“-Наука,М.1989