THERMAL REHABILITATION OF MULTI-FLATS BUILDINGS

Gheorghe BACANU

Abstract: The paper refers to a general unsuitable situation of the heating system in apartment blocks and proposes a possible technical solution in order to save energy. As is well know, in this kind of apartments the heating system is a common one, without the possibility to allocate acceptably the heat consumptions for each flat. Usually, the allocation of heat consumption by flat is made empirically, starting from the measurement made by a single heat flow meter, indicating the overall consumption. The individual consumption distribution is made, often, in function of the flats surfaces, which is, evidently, not in accordance with the real consumption.

Key words: heating system, energy saving.

1. Introduction

The European Union Directive 2002/91/CE prescribes that all member States of the European Union have to implement a national system for energetic certification of buildings in order to inform citizens about building thermal quality.

Rational use of energy in housing is not only a requirement of current building regulation, but a real challenge in the specific case of the apartment blocks built in all the Romanian towns!

The lecture presents a few ideas and solutions in the field of thermal rehabilitation of multi-flats buildings. Taking in account the specific (in Romania) situation in the subject of energy losses in buildings the authors propose a solution for the heat losses diminution especially by flat walls.

The paper refers, also, to a general unsuitable situation of the heating system in apartment blocks and proposes a possible technical solution in order to save energy.

2. Motivations

It is 4 major motivations (challenges) to act in order to improve the heating systems.

Social reason, having as purpose the control of thermal and investments charges by improving the thermal performance of a building (appropriate thermal comfort achievement) in order to limit the energy consumption and to unify the heat consumption related to different regions or different orientation of the buildings.

The simplification (encouragement) of regulations and innovations in this field which can give confidence to specialists in the optimum applying of them: simplest and flexible with minimum costs of the solutions;

Motivation related to the competitiveness of solutions on internal and external market referring to the computing methods and the building materials characteristics (defined by the European regulations).

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Motivation related to the environment protection, referring to the combat against the green house effect. As it is well know, different agreements (Rio, Kyoto, Bologna) fixed objectives in order to limit the gas emissions having greenhouse effect. The energy consumption of the buildings is responsible for producing a quarter of the gases with green house effect.

3. Requirements

- energy consumption limitation (reduction) in all the consumption forms (heating, hot water production, air conditioning, auxiliary equipments, lighting, etc.)
- referential values of the insulation of building’s different parts settlement;
- annually, predicted, evaluation of the entire forms of energy consumption;
- to take in account the possibility of changing the energy source(s) on the life time duration of the building;
- to record the energy consumption of a building in an own certificate
- thermal uncomfort limitation on summer time for the internal temperature by establishing of optimum values in correlation with different climate regions.

4. Objectives

- a coherent equilibrium of the quality of the building structure achievement: each part of walls, each links between walls, windows, terraces, etc., must have an appropriate insulation
- a conventional amount of energy consumption for a building, apart from his geographical location; this value can be expressed by a coefficient C (kWh/year), equivalent with the sum of different forms of consumption

![Diagram of annual energy balance of building](image-url)
The above scheme presents an annually energetically balance of a building and shows that an housing building must:

- have a good insulation, in order to reduce the energy loses in the winter time and to avoid if it is possible to use de air conditioning system in the summer time;
- have good orientation of the surfaces in order to optimize solar energy supply in the winter time and to protect against the overheating in the summer time.

The summer time comfort request refers to the inside temperature of the building, which must not surpass a settled value (25-26ºC), with all windows closed. This temperature depends on:

- the kind of the walls, the opaque and/or transparent surfaces, their orientation and inclination;
- the climatic zone;
- the thermal inertia of the building;
- the solar protection (roller/window blind).

5. Thermal Losses Computation

The outline (contour) of a building can be decomposed in different surfaces (walls), which at their turn can be decomposed in different building blocks:

- opaque or transparent wall surfaces:
  - external walls
  - terraces
  - bridging
- windows and doors
- junction lines between bridging and walls

For an appropriate thermal technical solution establishment in order to rehabilitate a building, is necessary to take in consideration the following factors:

- The insulation of walls, bridgings, roofs
- The thermal bridges
The type of windows and framework
- The ventilation system
- The heating and hot water system
- The place of construction

The insulation must be made from specific materials, having a thermal conductivity coefficient less than thus imposed. By thermal bridges it understand a space (zone) in which the insulation is interrupted causing energy losses.

6. Adequate Insulation of the Buildings

*Insulation thickness influence on overall heat transfer coefficient*  

<table>
<thead>
<tr>
<th>δ_{ins} [m]</th>
<th>0.02</th>
<th>0.03</th>
<th>0.04</th>
<th>0.05</th>
<th>0.06</th>
<th>0.08</th>
<th>0.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>\lambda_{ins} [W/m·grd]</td>
<td>0.035</td>
<td>0.035</td>
<td>0.035</td>
<td>0.035</td>
<td>0.035</td>
<td>0.035</td>
<td>0.035</td>
</tr>
<tr>
<td>K [W/m²·grd]</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>K_{ins} [W/m²·grd]</td>
<td>1.4</td>
<td>0.95</td>
<td>0.74</td>
<td>0.61</td>
<td>0.52</td>
<td>0.40</td>
<td>0.33</td>
</tr>
</tbody>
</table>

where

\[
K = \frac{1}{\frac{1}{\alpha_{f_1}} + \frac{\delta_w}{\lambda_w} + \frac{1}{\alpha_{f_2}}}
\]

\[
K_{ins} = \frac{1}{\frac{1}{\alpha_{f_1}} + \frac{\delta_w}{\lambda_w} + \frac{\delta_{ins}}{\lambda_{ins}} + \frac{1}{\alpha_{f_2}}}
\]

Fig. 3. *Thermal Bridges*
Obviously, it is not useful to purpose a new solution which is not profitable. To know if it will be profitable, it is necessary to compare the implemented resources and the results obtained.

The comparison between the investment cost and the sum of the anticipated incomes (after actualization) makes it possible to measure the profitability of a project. Generally, an investment is characterized by significant expenses over a relatively short period which generates later flows of incomes during all the lifetime of the investment.

The economic profitability determination of the investment based on the calculation of the financial benefit carried out is debatable, especially because of the fuel (conventional) price level which intervenes in the calculation, and which reflection is not the level on the world market at a given time.

For the determination of the energy recovery duration it is necessary to establish:

- the annual energy saving (in conventional fuel), $ES$, [in kg/year, or kWh/year];
- the energy incorporated, $EI$, in the products which constitute this installation, [in kg, or kWh].

With these elements, the energetic recovery time, $t_{ER} \delta$, $ER$, is determined with the relation:

$$t_{ER} = E_I / E_S \text{ (years)}$$
Energetic Recovery Time

Table 3

<table>
<thead>
<tr>
<th></th>
<th>kg</th>
<th>kgh/kg</th>
<th>kWh</th>
<th>COSTS (0.083 € / kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIALS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>15</td>
<td>16.16</td>
<td>242.46</td>
<td>20.12</td>
</tr>
<tr>
<td>M2</td>
<td>8</td>
<td>8.08</td>
<td>64.66</td>
<td>5.37</td>
</tr>
<tr>
<td>M3</td>
<td>12</td>
<td>12.12</td>
<td>145.48</td>
<td>12.07</td>
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<td>TECHNOLOGIES AND INSTALLATIONS (T&amp;I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>7</td>
<td>14.95</td>
<td>104.66</td>
<td>8.69</td>
</tr>
<tr>
<td>T2</td>
<td>3</td>
<td>12.83</td>
<td>38.49</td>
<td>3.19</td>
</tr>
<tr>
<td>I1</td>
<td>6</td>
<td>20.21</td>
<td>121.23</td>
<td>10.06</td>
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<tr>
<td>TOTAL MATERIALS + T&amp;I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>716.98</td>
<td>59.51</td>
</tr>
<tr>
<td>MANPOWER</td>
<td></td>
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<td>808.20</td>
<td>67.08</td>
</tr>
<tr>
<td>OTHERS</td>
<td></td>
<td></td>
<td>162.00</td>
<td>13.45</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>1687.18</td>
<td>140.04</td>
</tr>
</tbody>
</table>

To illustrate, for instance, the result of such calculation, hereinafter is presented the situation of an investment in insulating of an apartment having five rooms (kitchen, dining room, 2 bedrooms and bath room).

The energy saved/day, previously determined, is about 58.5 kWh/day, so:

\[
t_{RE} = 1687.2 \text{kWh} \div (58.5 \text{kWh/day} \times 30 \text{days}) = 1687.2 \text{kWh} \div 1755 \text{kWh/month} = 0.96 \text{months}
\]

As it can observe the investment payback is very interesting and the energy saving is not negligible. This method of calculation is more rational and with higher certainty, due to the fact that it is based on the energy included in all the products which constitute the installation and not on a so variable and unstable element as is the element which is related to the funds (price).

7. Rehabilitation of Heating System

The heating system in such apartment blocks, in the majority of cases, is designed as a vertical, different multi-columns solution of the heat distribution, meaning that one flat can have three, four or more heat supplying columns.

In order to have an image of the above mentioned heating system specific design, in fig. 1 is presented a simplified scheme of the system for a 5 floors apartment block. As it can see, one “standard” apartment having five rooms (kitchen, dining room, 2 bedrooms and bath room), due to the vertical heat pipes distribution, depending on the spatial distribution of rooms, has four or five points of heat supply for the five radiators installed in the five rooms. The individual consumption distribution is made, often, in function of the flats surfaces, which is, evidently, not in accordance with the real consumption. More than that, different flats can have different kind of radiators not only as type, but also as size!

As result, no cause to save energy long as nobody can take in account any action in this respect. By consequence, the overall flat heat consumptions can be measured by the same number of heat flow meters! This solution is not acceptable, being very expensive.

Also, the overall heat consumption is measured by an unique (single) flow meter. It is evidently that this system not...
allows distributing properly the individual heat consumption.

As consequence, in this kind of apartments is very difficult to allocate acceptably the heat consumptions for each flat. Usually, the allocation of heat consumption by flat is made empirically, starting from the measurement made by the (single) heat flow meter. The solution of providing flow meters for each point of heat supply is not a good solution, being very expensive.

The other solution of changing the entire heating system is, also, too expensive.

A technical solution for this problem is presented starting from a model of 5 floors apartment block, but, the solution can be generalized for many other kinds of blocks having the same vertical multi-columns distribution of heat system. The solution consists in a new design of the heating system, starting from the existing one.
Each apartment will have only one (different) point of heat supply (connecting pipe) using one of the columns passing through and the heating elements (radiators) will be connected by horizontal pipes, in chain (fig. 2.).

This solution allows installing a single heat flow meter by apartment and, by consequence, permits the establishment of the real heat consumption. In this case, everyone is motivated to do actions in order to save energy (and money) in accordance with his (their) needs and desired comfort conditions.

8. Conclusions

Taking in account that, in many cases, the apartment blocks are designed with vertical multi-columns distribution of heat system is very difficult to allocate acceptably the heat consumptions for each flat. The allocation of heat consumption, made empirically, not in accordance with the real consumption, determine less interest to save energy.

The solution of providing flow meters for each point of heat supply is very expensive. The other solution of changing the entire heating system is, also, too expensive.

The technical solution presented in this paper, having as model a 4 floors apartment block, consists in a new design of the heating system, starting from the existing one. Each apartment will have only one (different) point of heat supply (connecting pipe) using one of the columns passing through and the heating elements (calorifiers) will be connected by horizontal pipes, in chain. This solution allows installing a single heat flow meter by apartment and, by consequence, to establish the real heat consumption. In this case, everyone is motivated to do actions in order to save energy (and money) in accordance with his (their) needs and desired comfort conditions.

References