Influence of Radiation Losses from Heat Emitting Body on Building Energy Performance

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Influence of Radiation Losses from Heat Emitting Body on Building Energy Performance: *Kosovo as member of energy community treaty is in the path of implementing the EU Directive on the "Energy performance of buildings". Since the process is ongoing the elaboration of best practices and adoption of standards containing common methodologies for building energy performance assessment is on the early stage. Even though national calculation methodology for calculation of energy use for space heating and cooling is not adopted a extended number of energy audits in public building has been made, The purpose was to analyse the energy flow in a building, understand its energy dynamics, and seeks to propose and prioritize the measures for reducing the energy consumption according to the least cost effective opportunities. Those intervention measures aim not just to reduce energy consumption but also will improve the comfort level conditions. More than 200 public buildings – schools, hospitals, kinder garden, family health care centres etc. have undergone energy auditing process. By gathering this information and analyzing the findings in many cases appeared mismatch between consumed energy - measured by energy meters and calculated for baseline scenario which was one of the tasks.*

This facts brought the idea that further research is needed in order to identify the factors influencing the gap between baseline scenario, reported consumption, and analyse the accuracy of results affected to a great extent by calculation assumptions, boundary conditions and input values which in this case are taken for study state condition

Key words: *Building energy assessment, Energy Audit in Buildings, Thermography of building envelope, Heat losses.*

INTRODUCTION

Due to lack of national approved calculation methodology, during energy audits in buildings standards for calculating energy performance and procedures are applied according to EU- CEN standards. The first step of energy audit consisted with on-site visit-measurement with data collection regarding the layout of building, building physics characteristic, inventory of energy consumption appliances and installation, in order to calculate, identify and propose the most economical and energy-saving opportunity. A comparison between recorded/calculated energy consumption scenarios is analyzed including expected energy consumption after proposed measures are implemented. This process is conducted completely on substantive analytic procedures accompanied with onsite measurements related to internal comfort (temperature, humidity, illumination level), efficiency of installed boilers for heating system, flue gas analyzes, emission factors and heat loss visualization through building envelope using thermo graphic camera. Thermography have revealed-visualized a significant heat loss on external envelope especially on the area the wall behind the radiator filmed from outside.

CASE STUDIE

The analyses in this paper are concentrated in providing analytical approach toward the fact that significant energy losses are concentrated on outside un-insulted wall at the area where heat source - radiator is installed; high temperature concentration is measured and recorded right behind the radiator on outside wall surface decreasing on horizontal line going opposite direction from radiator position. To some extend this "unseen heat loss" which is visualized through thermography right behind the radiator on outer wall was very often measured and recorded in almost all cases which were undergone energy auditing. Therefore this study provides information on one of the factors among others that influence the mismatch between analytical calculation of energy consumption for current condition, reported energy consumption, and measurements using above described tool. Such discrepancy, influence and has the impact on indoor comfort level, the tendency of producing more energy to keep the level of comfort at desired level increased the fuel consumption while the produced energy is uncontrolled wasted. One typical uninsulated wall was selected as case study for analyzing the heat loss through the area right behind the radiator installed causing larger heat loss - dense heat flux and heat transmission on the outside surface, (fig 1)

The Secondary school is located in Suhareka, consists of two floors with total floor area of 4522 m^2, total external envelope (2040m^2 wall and 1027 m^2 windows)

The building is located in the medium density city and it is open to environmental effects. The wall selected for the analyses is 20m^2 consists of 6 m^2 brick wall 24 cm thickness and 14 m^2 window area, PVC frame double glazing faced north.

The transparency is on the entire façade of the building.

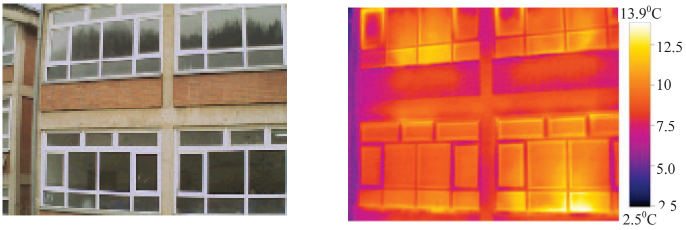

Fig.1. Thermography imaging of the building

HISTOGRAM AND PROFILE GRAPHS OF INFRARED IMAGES FOR THE CASE STUDY

For the case study the thermo camera TESTO 875-1i 320x240, detector 160x120 interpolated to 320x240 pixel, display High quality wide angle lens 32° measuring range - 20°C to +350° C, with thermal sensitivity 0.05, (50mK) was used.

Thermo imaging basically operates on absorption of the radiated energy by external wall captured by thermal-sensor. Histogram is graphical presentation of one image contrast and its intensity distribution, therefore the quality of detail capturing is important for accuracy of measurement of the heat flux , the temperature intensity is plotted on the x-axis and the percentage surface under same temperature range of the of wall is plotted on the y-axis fig 2.

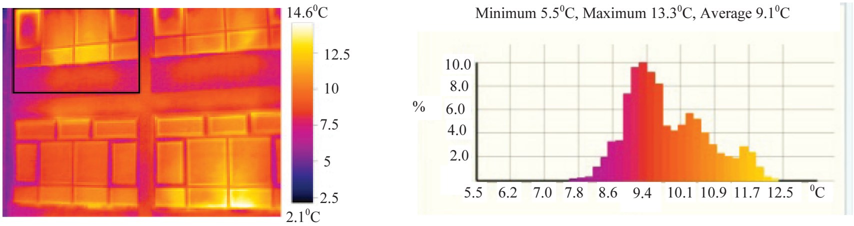

Fig.2. Relative distribution temperature within case study defined surface area of the outside wall

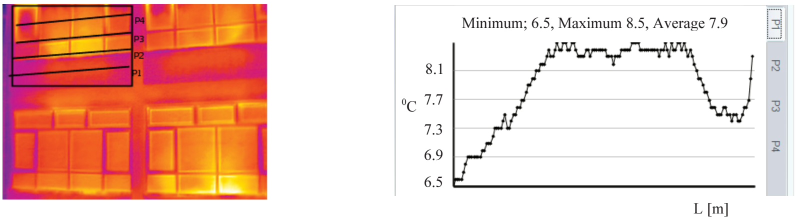

Fig.3. Thermo-gram and profile of temperature in the line P1

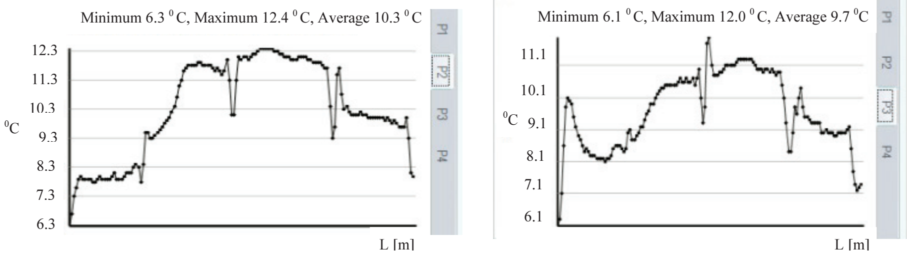

Fig.4. Profile temperature in lines P2 and P3

In this case presented in the thermo gram and profile of temperatures in the line P1 is noted significant difference in the same wall in the short distance the temperature deviation from 6.1 ate the end of the wall reaching highest 8.5 ^{0}C on entire surface on the area where indoor heating radiator is installed, (fig. 3).

ANALYZING OF HEAT LOSS DISTRIBUTION OVER THE SURFACE OF OUTSIDE WALL

The methodology applied in this case was to calculate extra losses and compare the results based on the idea of reaching the same indoor heat requirements by obtaining a simple energy balance in steady state condition. The general equation for calculation of nominal power of a Radiator, by neglecting of heat gains, may be presented in the following form:

$$Q_N = Q_{tr,ve} + Q_{extra} \qquad (1)$$

Where $Q_{tr,ve}$ - are the heating requirement to cover transmission and ventilation losses - independent of the heating system type,

Q_{exra} - are the extra heat losses associated with the type of heat emitting system that is used. In this case the heat emitting body is the radiator, extra heat losses are generated by heating from inside wall construction due to high radiator temperature and its close distance to the wall increasing the heat transmittance by radiation.

In order to have a feeling of intensity of extra losses a simplified model of steady state heat transfer from radiator back side to toward outside air is analyzed (fig. 5).

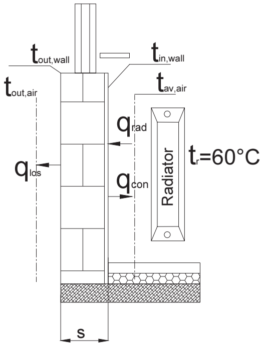

Fig.5. Heat transfer between radiator and outside wall

Heat transfer from radiator back side to the wall takes places by combined effect of radiation and convection heat transfer. For assessment of heat transfer by radiation, the formulas valid for specific heat transfer between two large parallel plates may be applied [1]:

$$q_{rad} = \sigma \frac{1}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} \left(T_{rad}^4 - T_{in,wall}^4 \right) \quad (2)$$

Where $\sigma = 5.67 \cdot 10^{-8} \left(W/m^2 \cdot K \right)$- is Stefan-Boltzmann constant, $\varepsilon_1, \varepsilon_2$- are heat transfer emission coefficient of radiator and wall surface respectively, $T_{rad}(K)$- mean radiator temperature assuming to be the same as radiator back surface temperature and $T_{in,wall}(K)$- temperature of the inside wall surface

According to the relevant studies of similar problem [2, 3, 4], due to the heat received by radiation, wall behind the radiator becomes warmer than surrounding air. Hence the heat absorbed by the wall, partially is transferred back by convection in the air between radiator and wall surface, but the largest part is lost outside by transmission through wall layers and by convection from outside wall surface to outside air.

Heat transfer from inner wall surface to the surrounding air can be calculated by using of common formula for convection heat transfer:

$$q_{con,i} = h_{wi} \left(T_{in,wall} - T_{av,air} \right) \quad (3)$$

Where convection coefficient h_{wi} on the inside surface of the wall may be calculated by using of following expression [4]:

$$h_{wi} = \frac{\left(T_{in,wall} - T_{av,air} \right) + 5}{35} \quad (4)$$

Where $T_{av,air}(K)$-represents average air temperature between radiator and outside wall

Heat losses through construction wall may be estimated from hat balance equation:

$$q_{loss} = q_{rad} - q_{con} \quad (5)$$

On the other hand, by neglecting radiation heat transfer from outside surface of the wall to outside air (law outside wall temperature), heat losses on the outside surface of the wall may be calculated also by using of convection equation:

$$q_{loss} = q_{con,o} = h_{wa} \left(T_{out,wall} - T_{out,air} \right) \quad (6)$$

h_{wo} is the outside wall convection coefficient.

If the wall surface temperatures, it's geometrical and thermal characteristics are known, heat losses can be calculated also by using of steady state conduction equation:

$$q_{loss} = q_{con,o} = \frac{k}{s} \left(T_{in,wall} - T_{out,wall} \right) \quad (7)$$

$k(W/m \cdot K)$-is the equivalent wall thermal conductivity and

$s(m)$ - Wall thickness.

In order to quantitatively compare specific heats appearing in eq. (5), the case visualized in fig. 3 is analyzed. In this case, average temperature on the outside wall surfaces is ca. 8.2 °C, measured indoor radiator temperature is 60 °C, wall thickness $s = 0.27\, m$, equivalent wall thermal conductivity $k = 0.6\, W/(m \cdot K)$ and outside air temperature 4.8 °C. By insertion of such values in equations 2-7, one can obtain as follows:

$q_{rad} = 100\, W/m^2$; $q_{con,i} = 20\, W/m^2$ and $q_{loss} = 80\, W/m^2$

This means that 80 % of heat transfer by radiation on the back side of radiator is lost through the wall to outside air. Of course the proportion between corresponding specific heats will change with changing the boundary conditions, but actually discussed case demonstrates the order and magnitude of heat losses compared to entire heat radiation on the back side of the radiator. The effect of radiation heat losses, in practice have to be compensated by producing additional heat power (Q_{exra} in equation 1) and delivering to the radiator, which should be considered in dimensioning phase of central heating system and sizing the radiators. However, due other heat loses factors (conduction through the building envelope, uncontrolled infiltration) this fact has a reflection to discomfort level which was reported during interviewing the personnel, even though radiators were dimensioned according to common engineering practice. On the other hand, adding of Q_{exra} to the transmission and ventilation losses means more energy consumption and higher operational cost. In such cases, measures preventing radiation heat losses may contribute significantly to improvement of EE of central heating systems. Based on similar analysis, carried out in different countries, for different climatic conditions and different wall insulation quality, a reduction of energy consumption up 5 % is very realistic for all buildings being in similar conditions in Kosovo. However, such EE measures have not been implemented yet but it represents a field which should be further analysed in order to implement low cost effective energy saving measures.

CONCLUSIONS

Current paper provides a qualitative description on impact of radiation heat losses through outside wall and it offers simple equations for analysis heat fluxes from radiator back side to the outdoor surrounding. It further indicates the potential for energy saving by preventing of radiation heat losses and provides a rough estimation on EE improvements which may be expected by reduction of such losses.

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This paper has been reviewed.