Теплопотери с перегретой части стены под радиатором

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Аннотация. В работе рассмотрены проблемы дополнительных теплопотерь через перегретую часть стены под радиатором. Проблемы данных теплопотерь рассмотрены с разных аспектов. В работе приведены результаты расчетов конвективного и радиационного теплообмена между наружной стеной и радиатором. Оценена разница потерь тепла между радиатором, установленным у наружной стены, и радиатором, установленным у перегородки. Выявлено, что через перегретую стень дополнильные потери могут составлять до 30% в зависимости от расстояния до стены, размеров стены и температуры жидкости в отопительной системе. В работе обсуждены различные возможные причины дополнительных теплопотерь. Рассмотрены причины, связанные с проблемами заводского изготовления радиаторов, проектирования систем отопления и размещения отопительных приборов. В выводах представлен набор рекомендаций для уменьшения и полного исключения данного вида теплопотерь.

Ключевые слова. Теплопотери, энергоэффективность, отопление, конвекция, радиаторы.

The heat loses through overheated zone of wall under radiator

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Abstract. The issue of the complementary heat loses through the overheated wall is considered from several aspects. The calculations of convection and radiation heat exchange between outer wall and radiator is provided. The amount of the heat loses of radiator installed by the outer wall is compared with the loses of the one installed by interior wall. It is found that 30% of extra more heat can leak outdoors through the zone under radiator. Different reasons of the complementary heat loses are discussed. Problems of manufacturing radiators, designing heating systems and placing the heating devices is considered as reasons related to the heat loses. Set of recommendations is suggested in the current paper for decreasing and avoiding the amount of the loses.

Keywords. Heat loses, energy efficiency, heating, convection, radiator.

Introduction. Heating is the biggest part of energy consumption of buildings. Heating of a building in Russia at a winter takes about kilowatt for each room. When designing a new building, heating system is a main point where it is possible to save energy on the design stage. Due to accustomed practice of installing radiators near the outer wall, engineers do what we call heating outdoors. Heating system works to warm up the outer environment which is absolutely unacceptable. On the picture 1 you can see photo of facade of a building made by thermographic camera in Russia at the winter time. These red spots under windows are overheated zones. You can see this situation on the majority of the buildings so the problem is very actual. This practice is wasting of energy sources. If all the new buildings are designed the same way, it will result in inefficient usage of energy sources and it make an impact to global warming and the climate change.

Пик. 1. Фасад от термографической камеры [5]
Current article aims following purposes:
modeling and calculating heat exchange process between radiator and outer wall;
analysis of results and assessment of heat losses through overheated zone;
suggestion of untraditional ways to avoid the additional heat losses.

**Materials and methods.** Current paper aims to analyze all aspects of the issue of overheated zone of the wall. It applies to different reasons of this problem from design of radiator itself to placement of it. Center of this scientific work is calculations all heat exchange processes that occur when radiator works. It is a calculation of convection and radiation of air from radiator to indoor environment, it also is calculation of convection and radiation between wall and radiator, and calculation of conduction of heat through wall.

Zone under radiator be 20 or more degrees higher, which makes serious impact to calculation. When make calculation for modeling the heat exchange process, we have to apply all the existing mathematical methods that necessary and make as realistic math model as it possible. In the literature we found a method for calculating convection of air between two heated surfaces of the same temperature [2], however our problem is two surfaces of different temperatures when both of them are warmer than ambient air. In the scientific work [3] author states about nonexistence of methodic of calculation of heat transfer by convection between two surfaces in open space. He provides experiment and finds Nusselt number experimentally. However, boundary conditions of his experiment do not match ours. He regarded one surface colder than ambient so it was heated by air as well. Therefore, we can confidently say that there is no methodic for convective heat exchange between two parallel vertical surfaces with different temperatures in open space. Methodic we used is about the same, but it is for closed space [4]. It is fit for situation when air is locked between radiator and wall and can explain situation of radiator closed by screen. For sure, in the real case, air is not completely open (picture 2) and not completely close. We cannot determine openness of the air for circulation. It depends on the situation and in all installed radiator is different.

![Image](image_url)

**Pic. 2. Air circulation and heat exchange for sides of radiator**

The model is analyzing the problem from scientific point of view, to understand real processes and give assessment for modern practices of mounting of heating systems.

**Results and discussion.** Heating systems are mostly presented by static heating with radiators. It is cheaper, easier to design and maintain. Most of all big cities such as Saint Petersburg in Russia have heating mains, so the dilemma between radiator heating and air heating and, maybe other is solved a priori. Heating systems are presented by radiators installed on outer walls, by the windows, hidden under windowsill.

Heating radiators mostly made of aluminum. This material has high thermal conductivity. Design of radiator provides heat supply from both sides of radiator. There is no front or back side of it, neither there is a thermal insulation of the back side or at least materials with thermal conductivity lower than aluminum. In simple words, when we put radiator by the wall, one side of it heats room, the other heats wall. Technically, we can install it in the middle of a room and it will work more efficient. Another example, when we put radiator on interior wall that separate two rooms. This way it will heat room with it one side, with another side it will heat adjacent room through wall. However, the heat energy...
still remains in the building and this is still efficient. When radiator installed in outer wall, there a loses due to overheating of the wall. Front side of the radiator exchanges energy with air of room by convection. Cold air during heating decreases in density and go up, while cold air goes down. This circulation increases heat exchange. Rear side of radiator exchanges with wall by convection in restricted volume. Air circulation there is confined with wall and windowsill (picture 3). Little of heat leaves this area and goes to room. Worse situation is when screens are installed by the radiators. Since air needs to circulate better to heat the room, these screens prevent and even completely block the circulation, directing all the power of radiator to wall or the screen itself.

To evaluate heat losses through overheated wall, calculation of heat exchange between wall and radiator and between radiator and indoor air were provided. Heat is transmitted by convection and radiation. Exchange between wall and radiator is determined as exchange between two vertical surfaces in restricted volume and described by formula [3]:

\[ P = 0.18(GrPr)^{0.25}S(T_r - T_w)/\delta. \]

Heat emission of radiator to air is [3]:

\[ P = 0.75(GrPr)^{0.25}\left(\frac{Pr_w}{Pr_r}\right)^{0.25}S(T_r - T_w)/\delta L. \]

Calculation were provided for radiator Purmo c11-500-1200 locked by niche and brick wall of 640 mm. Power of the radiator calculated is the same with the one declared by manufacturer \( P = 1400 \) W; Heat exchange by convection and radiation between outer wall and radiator when air is locked up between wall and radiator is \( P = 370 \) W; Therefore, heat loses in this case are 27% of the radiator’s capacity. When creating design of heating system, Russian code does not oblige to calculate additional heat loses through overheated part of wall, but gives magnifying coefficient from 1.05 to 1.13 [1].

We can access percentage additional heat loses through overheated zone experimentally with high accuracy by measuring temperature of the wall under radiator and in any other part of the wall and using formula [4]:

\[ q = \frac{ab(T_{wr} - T_w)}{AB(T_w - T_o)} \cdot 100\%, \]

where \( a, b \) – dimensions of radiator; \( A, B \) – dimensions of wall, \( T_{wr}, T_w \) and \( T_o \) – temperatures of wall under radiator, wall and outdoor temperature respectively.

For the purposes of ergonomics, engineers remove layer of wall or create niches (picture 4) to fit radiator in. When we consider heat loses through outer wall, we can see that conductivity is bigger as bigger is temperature gradient and smaller is thickness of the wall. In case of radiator installed in niche, wall is even thinner there, but surface temperature of wall under radiator is bigger than the one of in any other place. While temperature of inner surface of wall at winter be from 15 to 20 °C, wall under radiator be very overheated and might be more than 40 °C. It is obvious that this part loses more heat, but niches significantly increase these loses. In simple words, this way we heat outdoors, through thinner wall, this heating of outdoors be more advantageous.
actually does not. However, almost all the energy is transmitted by convection. That is why it is so important to provide air to circulate around it and avoid screens and other barriers for air. Sometimes engineers provide screens of tinfoil beside radiator. Tinfoil reflects infrared radiation. This misconception can result in even bigger heat losses, since thermal resistance of tinfoil is about nothing. In this work we calculated radiated heat exchange between radiator and wall. Kirchhoff’s and Stefan–Boltzmann’s equation calculate it with high accuracy:

\[ q_{rad} = \varepsilon C_0 \left( \frac{t_r}{100} - \frac{t_w}{100} \right)^4 \]

For radiator Purmo c11-500-1200 we got heat loses due to radiation of 2.24 Watt. It is far too low in comparison with convection. Radiation is matter at high temperatures of incandescent bodies at few hundred Celsius degrees. Therefore, neither tinfoil screens nor other screens against infrared radiation do not stop heat loses through overheated wall, but insulation with low thermal conductivity do.

One serious argument for placing radiator on outer wall is that wall could be frozen in winter. Actually, upper part of the wall is not affected by heat of radiator but with the heat of indoor air. And this upper part never be frozen, even though it does not contact with radiator. Therefore, removing radiator from outer wall and placing it anywhere in the room would not result in freezing of wall, because it will still contact with warm air of 20 degrees and be warmed up.

**Conclusion**

It is undeniable fact that today tendency in construction is energy efficiency. As was stated earlier, the highest energy losses be due to needs to heat a building at the winter. Today’s technology of designing heating systems in Russia is heritage of soviet times, when tasks in civil engineering was not intensive, but extensive, not efficiency but volume of works. Nowadays these outdated methods in design heating systems be harmful for sustainability of the buildings. While engineers should use progressive experience and high technologies today, researchers have to think not about past or today things but about challenges of tomorrow and even future after tomorrow. From these perspectives conclusions of current research are made. They stated as follows.

1. When it comes to radiator design, there should be radiators for outer wall and others. First ones should avoid possibility of emitting heat with it on side, placed to the wall. It can be material different from aluminum with lower thermal conductivity applied, or little amount insulation added to rear side. As an example of most energy efficient insulation we suggest vacuum as an insulation of the future. It can be made in the factory conditions very fast and metal radiator do not need special reinforcement to have vacuum inside.

2. Radiator can be placed under interior wall (picture 5). It is not going to be huge rectangular device we all accustomed to see. It will be compact low, but sometimes long device, whose small area of heat exchange will be compensated with big number of fins, which will provide better heat emission. Example is low long radiators with two or more convectors, which have capacity as traditional ones. This way we avoid heat losses through overheated wall which could reach more than 25% of radiator’s capacity, as calculations shown.

![Radiator installed by interior wall](image)

3. Since zone of radiator has higher temperature gradient it will need thermal resistance higher than other parts of the wall. Therefore, when radiator is installed on outer wall it needs additional insulation. And important thing there is that it cannot be infrared radiation reflecting screen, because they have zero efficiency in this case.
4. Using niches and screens for radiators is absolutely unacceptable. First ones not only reduce thermal resistance of the wall but also confines air in small volume, preventing circulation enforcing convection process. Some screens could lock radiators in a closed chamber, which are heated but do not exchange heat with rest of the room. The open radiator is, the more intense the convection and heat exchange with indoor air is.

All ideas above are related to the topic of heat losses through overheated zone of the wall under radiator and are conclusions of our calculations. This topic leads to more global idea of energy efficient and sustainable building. Near future is going to lack energy resources but have dramatic increase in world population and buildings as well. For now, one of the challenging tasks is to solve problem of inefficient heating systems of buildings. It will lead us to energy efficient and sustainable future.

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**Дополнительная информация**

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