Innovative Energy & Research
ISSN: 2576-1463
Research Article Open Access

Investigation into the Impact of Decorative Covers on the Thermal Efficiency of Low-Pressure Hot Water (LPHW) Radiators

Issa Amaish* **and Oleg Stolyarov**
Institute of Civil Engineering, Peter the Great St. Petersburg Polytechnic University, St. Petersburg, Russia

Abstract

This study investigates the impact of decorative wood covers on the heat output and efficiency of low-pressure hot water (LPHW) radiators used in heating systems of buildings in Russia. The study compares the heat output of two scenarios: a wood panel covering radiator, and a radiator without any cover. The experiments were conducted under steady-state conditions within a closed room environment, ensuring a controlled room temperature. The results show that the application of decorative wood covers resulted in a reduction of radiator efficiency by 13-20% compared to traditional uncovered radiators. The findings underscore the influence of wood covers on the performance of heating systems, thereby affecting their energy efficiency. The insights gained from this study have practical implications for optimizing the design and operation of heating systems, aiming to enhance energy efficiency and thermal comfort in various building applications. Further research in this area can provide valuable insights for the effective utilization of wood covers, leading to improved energy performance and occupant comfort.

Keywords: Low pressure hot water radiators; Heating systems; Decorative wood covers; Heat output; Thermal comfort

Introduction

In accordance with the regulations set forth by the Ministry of Construction, Housing, and Utilities of the Russian Federation concerning the energy efficiency standards for buildings and structures, a mandatory 20% reduction in the specific consumption of thermal energy for heating and ventilation is stipulated from July 1, 2018. This reduction is to be applied in comparison to the specific consumption levels of thermal energy for heating and ventilation prevailing prior to the aforementioned date [1]. In this context, the construction industry holds significant potential. The regulation of heating, ventilation, and cooling within buildings constitutes 60% of the overall energy consumption and contributes substantially to CO2 emissions. As a result, there is a growing need for heating systems that are both environmentally efficient and tailored specifically for applications such as heat pumps and district heating systems. These heat emitters enable a lower system water temperature while maintaining the same heat output as traditional systems, thereby facilitating energy savings in both heat production and distribution [2].

The heating system in St. Petersburg, Russia, functions as an open system, wherein domestic hot water is directly drawn from the heating system. This distinctive open system was specifically engineered to address the pronounced corrosion resulting from corrosive water, setting it apart from conventional global heating systems typically linked to central heating facilities [3]. Radiator surfaces, when operating, can attain elevated temperatures, necessitating the implementation of safety measures or considerations for aesthetic appeal, such as the use of decorative casings. These casings are frequently crafted from timber and incorporate fascia grilles or openings. Both design configurations significantly influence the heat transfer dynamics from radiators to heated space. While numerous studies have concentrated on evaluating the thermal efficiency of radiators by analyzing heat emission in relation to energy input, an alternative perspective on efficiency scrutinizes the radiators' effectiveness in heating occupied spaces.

While certain radiator manufacturers incorporate stoneware panels for aesthetic purposes, they assert that these panels concurrently enhance the thermal energy properties of the radiators. The justification for employing stoneware panels extends beyond visual appeal to encompass improvements in thermal performance [4]. In instances where lower supply temperatures are employed, as is common with heat pumps, the thermal output from radiator surfaces will naturally decrease, leading to a reduction in the heat input to the indoor environment. To counteract this, various technical solutions have been proposed to enhance the efficiency of heat emitters. These solutions include enlarging the surface area of heat emitters or employing forced convection using air blowing.

The objective of the city's heating supply system development and reconstruction is to enhance the reliability and quality of heating and hot water supply [5]. This study is dedicated to a comprehensive examination of heat emission and system efficiency in the context of two distinct configurations: uncovered radiators and radiators encased within decorative casings. The investigation aims to provide valuable insights into the thermal performance and overall effectiveness of these radiator types within heating systems. This research aligns with the broader scientific exploration of heating technologies and contributes to the ongoing discourse on optimizing thermal efficiency in building environments.

Heating systems in buildings, generally comprising radiators, floor heating, or their combinations, account for an increasingly significant proportion of energy consumption within the building sector [3].

As an illustration, the predominant energy end-use in the building sector in the UK is space heating, representing more than 60% of delivered energy and exceeding 40% of energy costs [3,6]. A study in 1980s indicated that over two-thirds of the energy savings achievable

***Corresponding author:** Issa Amaish, Associate Professor, Institute of Civil Engineering, Peter the Great St. Petersburg Polytechnic University, St. Petersburg, Russia, Email: issaamaish@gmail.com

Received: 11-Nov-2023, Manuscript No: iep-23-122357, **Editor assigned:** 13-Nov-2023, PreQC No: iep-23-122357 (PQ), **Reviewed:** 24-Nov-2023, QC No: iep-23-122357, **Revised:** 29-Nov-2023, Manuscript No: iep-23-122357 (R), **Published:** 30-Nov-2023, DOI: 10.4172/2576-1463.1000371

Citation: Amaish I, Stolyarov O (2023) Investigation into the Impact of Decorative Covers on the Thermal Efficiency of Low-Pressure Hot Water (LPHW) Radiators. Innov Ener Res, 12: 371.

in buildings would come from space heating. Research carried out in the United Kingdom forecasted a potential energy-saving of up to 70% in heating [3,6].

Research studies have indicated additional heat emission losses of up to 5% in older buildings with inadequate insulation, contrasting with less than 1% in newly constructed buildings featuring effective insulation [7]. The overarching trend toward low-energy standards poses a novel challenge for heating systems. It is apparent that the diminishing heating requirements entail reduced control and system losses in comparison to extant buildings characterized by higher heating energy demands [3].

The low-pressure hot water (LPHW) system is known for its efficiency and lower power consumption compared to other heating systems. However, the utilization of wooden covers may affect the functionality of the system. Therefore, this study aims to investigate the impact of these covers on the efficiency of the LPHW system and provide improved solutions for enhancing its overall efficiency and functionality.

Methodology

The temperature difference between the radiator and the surrounding air serves as the driving force for these heat transfer mechanisms. This difference determines the rate at which heat is released from the radiator and distributed into the room, ultimately influencing the overall heating efficiency. The following methodology was conducted to study the radiators' heat emissions (Table 1).

Selection of radiators and decorative covers

A range of LPHW radiators and corresponding decorative wood covers were selected for the study. The radiators were chosen to represent a variety of sizes.

Thermographic survey: a thermographic survey was conducted to measure and compare the heat output of different radiator configurations. The three configurations examined were: Group (A) bare radiators without any cover were place on the 3rd floor of the university building, group (B) radiators installed under wooden covers are placed on the 4th floor, and (C) considered as a control radiator because it has an unsimilar condition because it is not functionate well; all placed in the same controlled environment in a multistory university building of Peter the Great St. Petersburg Polytechnic University (St. Petersburg, Russia).

Thermal imaging: a thermal imaging camera was used to capture and monitor temperature distributions across the radiator surfaces and surrounding areas. This provided a comprehensive visual representation of heat patterns and variations.

Data analysis: The collected temperature and heat output data were analyzed using the Smart View thermal imaging software. The heat emission and efficiency of each radiator configuration were calculated and compared to determine the impact of the decorative wood covers on radiator performance.

Result interpretation: The findings were interpreted and discussed in the context of the research objectives. The effects of the decorative covers on heat output and system efficiency were analyzed, considering the potential implications for energy consumption and thermal comfort.

Results and Discussion

The thermographic survey revealed significant disparities in heat emission among different radiator configurations. Uncovered radiators (A1, A2, and A3) attained maximum temperatures of 63°C, 55.8°C, and 63.6°C are shown in Figure 1, 3 and 5, respectively. Conversely, radiators covered with wooden covers (B1, B2, and B3) displayed lower maximum temperatures of 44.8°C, 40.2°C, and 45.2°Care shown in Figures 2, 4 and 6, respectively. Notably, both groups were connected to the same water line, with A1 situated on the third floor and B1 on the fourth floor, ensuring comparable operating conditions.

Furthermore, the covered radiators (group B) exhibited a noticeable decline in heat output compared to the uncovered radiators (group A). Group B radiators' performance resembled that of a poorly functioning radiator, denoted as C1, which emitted a maximum temperature of 39.2°C. The average emitted temperatures for group (A) radiators were 50.5°C, 46.6°C, and 48.1°C, respectively. In contrast, group B radiators recorded average emitted temperatures of 28.3°C, 26.4°C, and 27°C, respectively. Notably, the poorly functioning radiator c1 had an average emitted temperature of 27.2°C as shown in Figures 1-7.

These findings highlight a significant decrease in heat emission efficiency when comparing the covered radiators Group (B) to the uncovered radiators Group (A). The disparity in heat output is substantial, with a reduction of approximately 28.5% in maximum temperatures and 43.7% in average emitted temperatures for group (B) radiators relative to group (A) radiators.

The adverse impact of wooden covers on heating system functionality becomes evident, given the comparatively lower heat emission levels from group b radiators. Notably, the LPHW system has been in use since the 1950s, neglecting a longstanding issue affecting system efficiency.

The findings demonstrate a discernible temperature pattern across the walls surrounding the radiators. Specifically, on the 3rd floor, the wall areas adjacent to the uncovered radiators Group (A) exhibited a peak temperature of 23.6°C. In contrast, on the 4th floor, the wall sections encompassing the uncovered radiators Group (B) displayed a notably lower maximum temperature of 19.2°C. This temperature difference is significant, with uncovered radiators achieving 18.6% lower maximum temperatures compared to the covered radiators, which measured 23.6°C. Likewise, the average temperatures reveal a conspicuous distinction, as depicted in Figures 8 and 9. On the 3rd floor, the average temperature is around 24.2°C, while the 4th floor records a slightly lower average by approximately 2°C.

Similar temperature variations are evident in the floor areas due to the presence of wooden covers. Both the 3rd and 4th floors demonstrate that uncovered radiators yield higher maximum and average temperatures relative to radiators concealed by wooden panels,

Table 1: List of the analyzed radiators Designation.

List of the analyzed radiators Designation	Radiator			Type	Floor
A	A1	A2	A3	Uncovered	Third
B	B1	B2	B3	Covered	Fourth
C	C1	--	--	Uncovered	Third

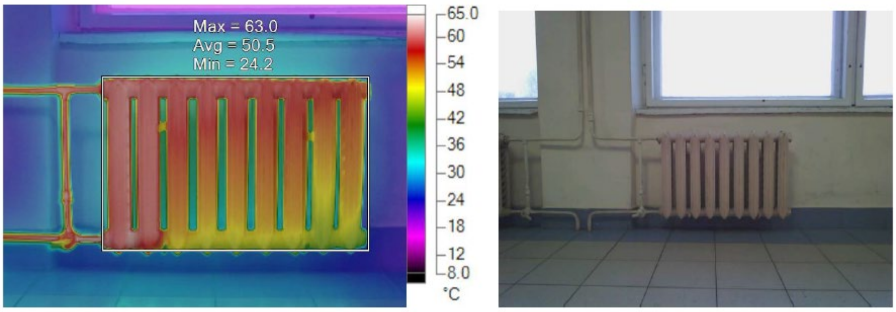

Figure 1: Thermographic and normal picture - Radiator A1 (Amaish, Personal collection, Dec 2022).

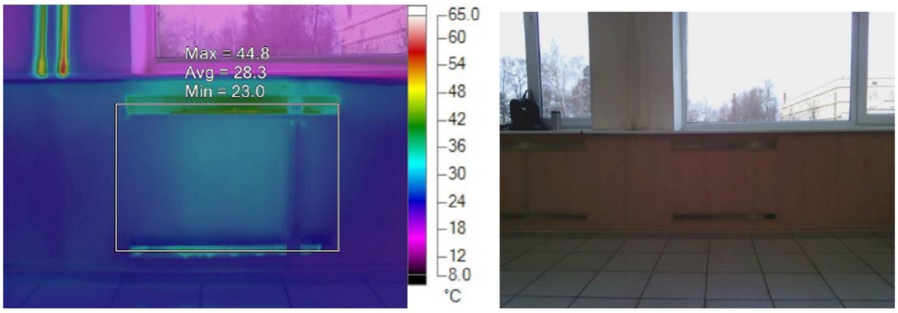

Figure 2: Thermographic and normal picture - Radiator B1 (Amaish, Personal collection, Dec 2022).

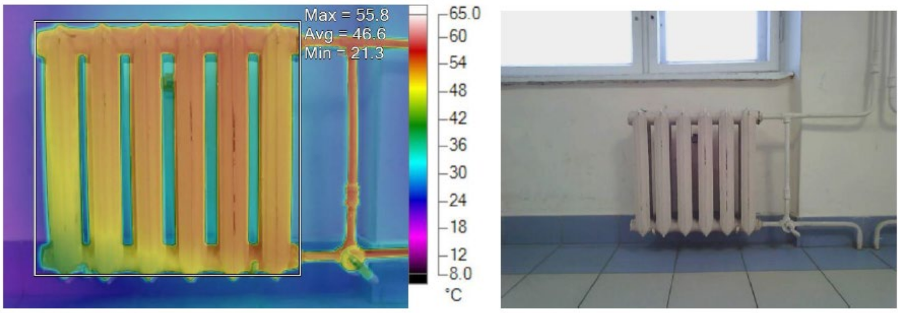

Figure 3: Thermographic and normal picture - Radiator A2 (Amaish, Personal collection, Dec 2022).

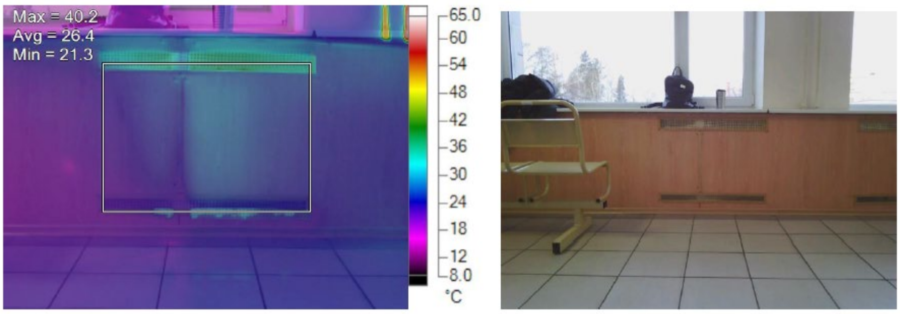

Figure 4: Thermographic and normal picture - Radiator B2 (Amaish, Personal collection, Dec 2022).

as indicated in Table 2. Notably, the average temperature exhibits a reduction of temperature by about 2°C between the two groups across both floors, indicating nearly 8% decrease in efficiency. This discrepancy highlights the wooden covers' capacity to curtail heat transfer to the floor regions, consequently leading to lower temperature levels.

Furthermore, the examination of temperature variations in the ceiling area between groups A and B radiators on the 3rd and 4th floors, respectively, provides valuable insights into the thermal effects of decorative wooden covers on heat emission efficiency. Group (A) radiators, featuring decorative wooden covers, exhibited maximum temperatures of 24.9°C and average temperatures of 24.2°C. In contrast, Group (B) radiators, also with decorative wooden covers, demonstrated lower maximum and average temperatures of 22.5°C and 21.7°C, respectively. This disparity, highlighting an efficiency reduction of around 10%, underscores the discernible influence of wooden covers on radiative behavior.

Wood is a natural insulator, and its thermal conductivity can affect the heat transfer characteristics within the system.

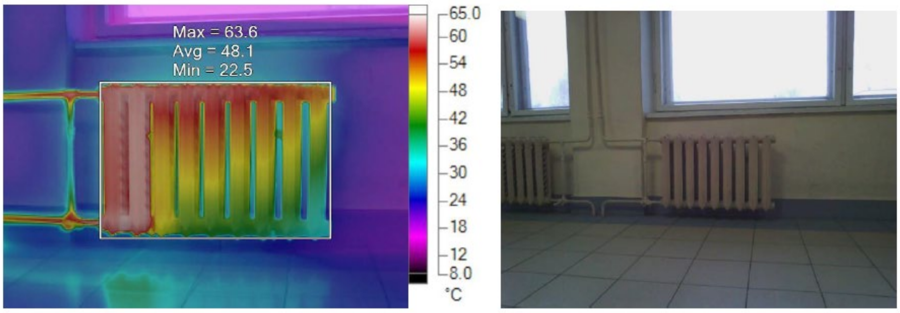

Figure 5: Thermographic and normal picture - Radiator A3 (Amaish, Personal collection, Dec 2022).

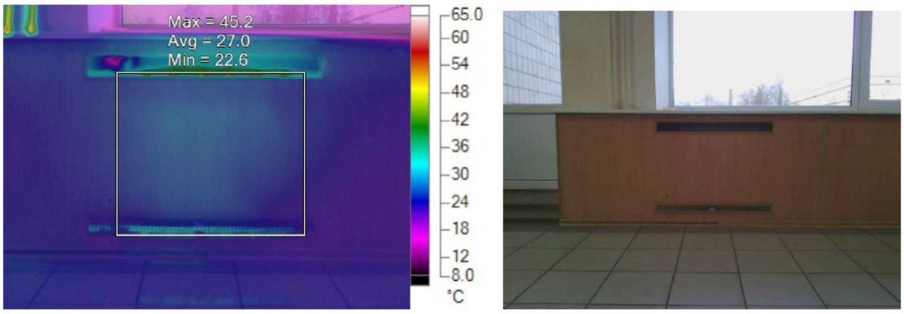

Figure 6: Thermographic and normal picture - Radiator B3 (Amaish, Personal collection, Dec 2022).

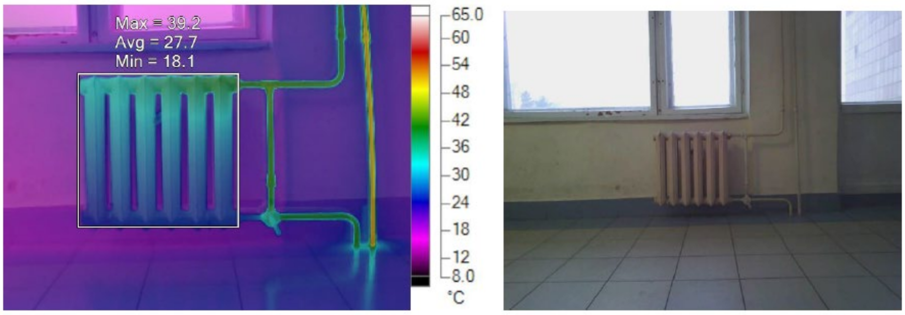

Figure 7: Thermographic and normal picture - Radiator C1 (Amaish, Personal collection, Dec 2022).

Table 2: Thermographic temperatures results.

3rd Floor - Group (a)						4th Floor - Group (b)				
Wall		Floor		Ceiling		Wall		Floor		Ceiling
Max T (℃)	22.6	23.6	26.5	26	24.9	19.3	19.2	23	23	22.5
Avg. T (℃)	21.3	22.2	23.8	24.5	24.2	17.5	17.7	22.1	22.6	21.7
Min T (℃)	18.6	21.1	22.8	23.9	23.7	15.4	16.1	21.4	22.1	20.5

Figure 8: Group (a) radiators effect on the walls and the floor (Amaish, Personal collection, Dec 2022).

Figure 9: Group (b) radiators surrounding effect on the walls and the floor; (Amaish, Personal collection, Dec 2022).

Empirical investigations have revealed that the thermal conductivity of wood is subject to variations influenced by factors such as wood species, moisture content, and density. In general, wood exhibits lower thermal conductivity when juxtaposed with metals or other materials typically employed in radiator construction [8]. The insulating characteristics of wood have the potential to impede the heat transfer from the radiator surface to the surrounding air. Moreover, the thermal resistance of wooden covers is influenced by both their thickness and design. Increased thickness may offer heightened insulation, consequently leading to a more pronounced reduction in heat transfer. Nevertheless, an excessive thickness might impede convective heat transfer, giving rise to stagnant air pockets and, consequently, diminished efficiency [9] (Figures 10-13).

The detected temperature fluctuations in the nearby wall and floor regions carry significance for both occupants' thermal well-being and energy efficiency considerations. The employment of decorative wooden radiator covers seems to curtail the degree of heat transmission to neighboring surfaces and surrounding area, as visually depicted in the 3D-IR images Figures 14 and 15. This phenomenon has the prospective effect of reduction localized thermal unease while concurrently fostering the potential for conserving energy, achieved by restricting heat dissipation through the building envelope.

The temperature discrepancy observed in the ceiling area between Group A and Group B radiators underscores the notable role of decorative wooden covers in shaping heat distribution dynamics. The application of such covers introduces an insulating effect that curtails the convective and radiative processes contributing to efficient heat dissipation. This outcome aligns with the initial conjecture that wooden covers impede the inherent mechanisms driving effective heat transfer from the radiators. The cooler temperatures observed in the ceiling region of Group B radiators echo a potential decrease in heat dispersion, which resonates with objectives centered around energy conservation.

The outcomes of this investigation underscore the sensitivity of heat emission efficiency to the presence of decorative wooden covers, particularly in the ceiling area. While these covers confer aesthetic enhancements, their discernible influence on heat distribution necessitates judicious consideration within the realm of energy-efficient heating systems. The efficiency decrement of approximately 10% brings to light the nuanced balance between visual aesthetics and energy preservation.

Conclusion

In conclusion, this study has conducted a comprehensive

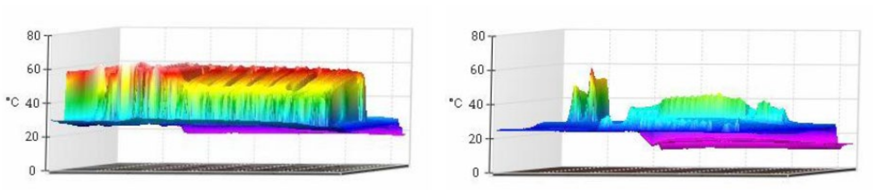

Figure 10: (a1 -b1).

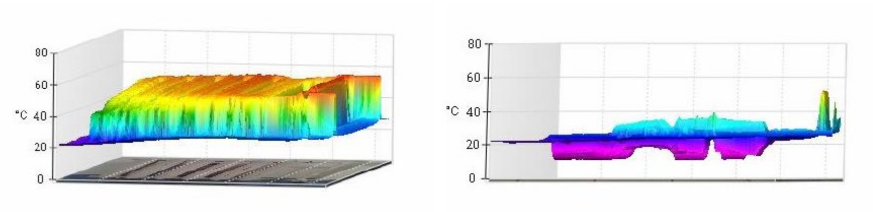

Figure 11: (a2-b2).

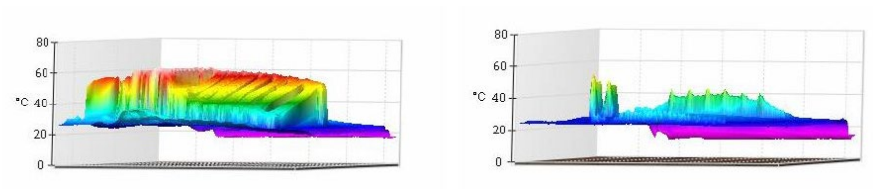

Figure 12: (a3-b3).

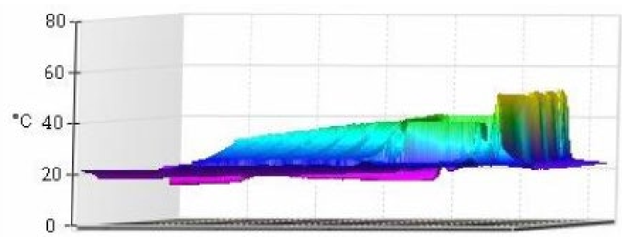

Figure 13: Line 4 R 3rd L 4th (c1).

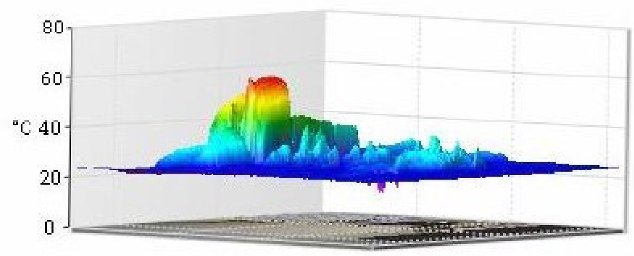

Figure 14: The surrounding effect of the radiators.

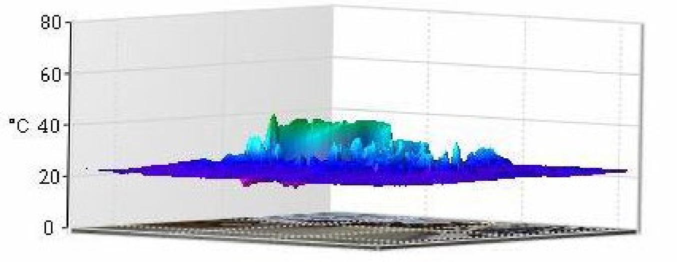

Figure 15: The surrounding effect of the radiators.

investigation into the repercussions introduced by the incorporation of decorative wooden covers upon the thermal performance and efficiency of (LPHW) radiators. The empirical outcomes illuminate a discernible diminution in the efficiency of radiators adorned with ornate wooden covers in contrast to both their unadorned counterparts and radiators exhibiting sub-optimal operational conditions.

The findings unveiled herein underscore the adverse impact exerted by the affixation of decorative wooden covers onto LPHW radiators, precipitating a consequential perturbation within their thermal performance and holistic efficiency. The discerned reduction in radiative efficacy implies an impedance in the conductive pathways facilitating the convection of heat from the radiator's surface to the contiguous ambient milieu. This curtailment in heat emission efficiency portends an ostensible elevation in the energy consumption necessary to realize and sustain the designated room temperature, thus potentially encumbering the fabric of thermal equilibrium.

The commensurability observed in the efficiency manifestations between the encompassed radiators and their functionally impaired counterparts engenders an intricate inquiry into the efficiency of decorative wooden covers in amplifying the radiative capacity. This observation proffers an inference that these ornate covers might engender an interference with the inherently resident convection and radiation processes, thereby impeding the coherent transference of thermal energy from the radiator to the proximate surroundings.

The implementation of these wooden covers concurrently portends a discernible moderation in the temperatures evident in the encompassing walls and floors, thereby denoting a feasible curbing in the directionality of heat transfer vis-à-vis the contiguous surfaces. This perceivable phenomenon augurs implications for the optimization of thermal comfort, by mitigating the propensity for excessive thermal gradients to manifest within the proximate architectural confines.

The pronounced decrement in operational efficiency witnessed in the radiators veiled by the wooden covers accentuates the imperativeness for intensified inquiry into the iterative evolution of the design and optimization paradigm for decorative cover implementations within the domain of heating systems. In the continuum of this trajectory, prospective research endeavors shall be balanced to elucidate alternative materials for cover fabrication or innovative design paradigms that reconcile the propensity for heat transfer degradation with the imperative of preserving aesthetical attributes.

The optimization of energy efficiency and increase of thermal performance are quintessential objectives within contemporary heating system paradigms. This warrants exploration into strategies fostering a reduction in energy loss coupled with a fortification of thermal emission propensities. Such a dynamic may involve the assessment of alternative radiator cover typologies or an exploration of pioneering technologies that catalyze augmented convective and radiative processes, whilst harmonizing the innate artistic aesthetic.

To encapsulate, the study explained that the incorporation of decorative wooden covers on radiators engenders a tangible impact on heat distribution in the ceiling area, resulting in an efficiency reduction of approximately. These findings underscore the intricate interplay between visual design and energy efficiency in heating systems, thereby instigating further exploration into cover design refinement to optimize both aesthetic appeal and heat distribution efficacy. This research enriches the knowledge base for architects, engineers, and policymakers striving to harmonize architectural aesthetics with energy-efficient heating solutions.

References

1. Approval of Requirements for Energy Efficiency of Buildings and Structures. Ministry of Construction: Housing and Utilities of the Russian Federation Order of 1550/pr on 2017.
2. Jonn Are Myhren, Sture Holmberg (2012) Performance evaluation of ventilation radiators. Applied thermal engineering.
3. Laurence Bradya, Mawada Abdellatif b, Jeff Cullenc, James Maddocksd, Ahmed Al Shamma'ae (2016) An investigation into the effect of decorative covers on the heat output from LPHW radiators. Energy and Buildings 133: 414-422.
4. A Menendez-Diaz, C Ordonez-Galan, JB Bouza-Rodriguez, JJ Fernandez-Calleja (2014) Thermal analysis of a stoneware panel covering radiators. Appl. Energ.131: 248-256.
5. Jonn Are Myhren, Sture Holmberg (2008) Flow patterns and thermal comfort in a room with panel, floor and wall heating. Energy and Buildings 40: 524-536.
6. H Herring, R Hardcastle, R Phillipson (1988) Energy Use and Energy Efficiency in UK Commercial and Public Buildings up to The year 2000. Energy Efficiency Series, Energy Efficiency Office, UK, (ISBN 0-11-412903-7).
7. BW Olesen, M Carli (2011) Calculation of the yearly energy performance of heating systems based on the European Building Energy Directive and related CEN standards. Energy Build 43: 1040-1050.
8. Zelinka SL, Glass SV, Boardman CR (2010) Wood Handbook—Wood as an Engineering Material. Thermal properties of wood.In: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.
9. Sadeghi M, Jokar M, Broumandnia A (2017) Numerical study of natural convection heat transfer in a radiator covered with a wooden enclosure. Applied Thermal Engineering 127: 1167-1176.