Fachhochschule Dortmund
University of Applied Sciences and Arts

„Examination of existing heating surfaces such as radiators, convectors and panel-type radiators as to their applicability for cooling during summer season in residential buildings“

Examination of existing heating surfaces for the purpose of cooling during summer season in residential buildings

Research post:
Fachhochschule Dortmund
University of Applied Sciences and Arts
Department of Architecture
Emil-Figge-Str. 40
44227 Dortmund

Project leader:
Prof. Dipl.-Ing. Arch. Armin D. Rogall

Project processing:
Dipl.-Ing. Manuel Pampuch,
Dipl.-Ing. Daniel Horn

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6. Summary

Within the context of this research project titled „**Examination of existing heating surfaces in residential buildings such as radiators, convectors and panel-type heaters as to their applicability for cooling during the summer season “** under the project leadership of Prof. Rogall and funded by the Ministry of Construction, existing panel-type radiators of a dual pipe system were fed with cold water in order to measure the occurring real cooling effect. Principally, the subject matter revolved around the following question: „Can a temporary cooling effect be achieved by using heating elements?“ In the wake of the summer of the century back in 2003, during which especially the elderly in need of care were suffering from the tremendous heat claiming a high number of casualties in Paris, the question was to be answered as to whether heating elements activated with cold water could possibly avoid an overheating of rooms as anticipated through climatic change. Within the east wing of the department of architecture of the Fachhochschule Dortmund, University of Applied Sciences and Arts, a central heating system was fed via the district cooling system. Within three rooms - two reserved for the experiment and one reference room without cooling - both temperature and humidity reaction was examined during the summer season from July until September.

During all measuring series, a temperature layering set in soon after the operation of the cooling element (converted panel-type radiator) was started, measured at levels according to DIN EN ISO 7726. The average divergence of temperature between ankle and head was at 5 Kelvin which all test persons experienced as very pleasant on warm summer days. Especially at the lower levels of the rooms where desks are arranged in offices and beds in nursing homes and hospitals, this temperature layering is of great advantage. Even on hot summer days, the maximum room temperature at head level reached approximately 26 ° C - the limit of what was felt to be comfortable. It is important to note that a sun shield was not used in oder to allow a natural thermal stress through morning sun rays. All experiments proved that this thermal stress could be compensated through the cooling surfaces. Through values taken from actual measuring, a cooling performance of around 180 Watt per cooling surface (approx. 0,59 m2) was determined. From this, the conclusion can be drawn that the higher the maximum day temperatures under the influence of direct sun light, the greater the cooling performance of the converted heating element.

All test persons involved described the onset of the cooling effect as positive, however, some of the measurements intended for the summer period of 2008 and 2009 could not be carried out as planned due to same participants contributing to the failing of some experiments by way of their airing habits. It was impossible to influence these habits, despite measuring results showing that on hot summer days air indoors tends to heat up and becomes moisturized through open doors and windows rather than cooling down. Although the vicinity of cool surfaces close to desks were sought by the participants, the desired temperature layering that before was experienced as pleasant was thus destroyed by turbulences deriving from incorrect ventilation/airing.
The office users were of the opinion that the air inside would become “more pleasant and fresher“ through open doors and windows. The so-called “fresh feeling“ was more dominant with all test persons than the feeling for the temperature within the “comfort zone“. It was also evident during cooling operation that cross airing for a short time works better and is more effective and energy-saving than permanent airing through tilted windows. However, the test persons felt more comfortable with tilted windows, with or without cooling.

In order to achieve measuring results under conditions similar to residential buildings, the sun shield was not used, causing the indoor temperature to rise naturally. For this purpose, two office spaces (room 2.05 and 2.06) were chosen on the second floor which were normally not used on a regular basis. Inside these rooms, and in one other room for reference, a device for establishing measuring data, equipped with temperature- and humidity sensors according to DIN EN ISO 7726 was installed. In addition, a weather station was installed on the roof. Nine measuring phases were carried out altogether. During measuring phase 1, preliminary measuring with a hygro- thermograph was carried out, giving an overview of the temperature- and humidity reaction of the building. Technically, a typical summery rise in temperature across the east facade of the building was recorded in measuring phase 2 inside a cooled room (initial temperature constant at 13 °C) and one room which was not cooled. During measuring phase 3, the initial temperature of the cooling system was at first raised to 16 °C in order to avoid system condensation. During the further course of this phase, the cooling in room 2.05 was turned off again to record its natural rewarming.

Although the summer of 2008 was characterized by a mean temperature which was 1 K higher than the summer of 2007, there was no significant hot spell with maximum day temperatures of more than 30 °C and so-called „tropic nights“ with outdoor temperatures of at least 20 °C. Subsequently, some measuring series that had already been carried out in 2008 were repeated during the summer of 2009. In order to simulate a hot summer period, the rooms No. 2.05 and 2.06 were artificially heated by using a fan heater during measuring phase 4. During measuring phase 5, cooling - both with and without the support of a fan which was installed above the cooling element – was achieved. In order to imitate the same level of humidity analogous to residential buildings where higher levels of humidity develop inside through plants, bathroom use, cooking and finally through the residents themselves, the air was dampened during the last measuring phase in 2008 with the help of an ultra sound air humidifyer. Due to the extension of this research project, some measuring series were repeated in wait for hotter periods during 2009, yet the series were not analysed further due to the lack of a typical hot spell that could have lead to different measuring results. All measuring series proved that heating elements are well suited for cooling, even though a higher cooling performance is desired with greater differences between out- and indoor temperatures (see date of 31 July 2008). Soon after starting the cooling operation, a temperature layering set in at workplace-level during the course of all experiments which was felt to be pleasant.

It is well possible to reach the point of adiabatic cooling where dew develops alongside. This is the case at preliminary room temperatures of 13 °C and lower and a surface temperature of the cooling element at 15 – 16 °C. However, the collected condensation water drops immediately evaporated due to constant low levels of relative humidity inside the rooms used for the experiments. Approximately 500 ml of condensation per cooling surface was determined within 24 h (02 July-03 July 2009). Experiments during which the temperature was raised through heaters, a rise in absolute humidity was registered that could not be explained by the use of the building. During the moisturizing experiment, a compensation of humidity and evaporation was observed inside room 2.05 and 2.06 caused by the light construction of the partition wall. The support of the fan installed above the cooling surface did not lead to a significant rise of the cooling performance. This is explained by the minor difference between surface- and air temperature as well as heat-transmission resistance on the surfaces.

As a result it can be said that negative effects known from heating systems operations through the habit of users will have an ever more drastic effect when it comes to cooling operation if more buildings in Germany were to be actively cooled due to climatic change. The reason being that positive parameters are more susceptible to disturbing factors. It has become clear that a converted heating system works sufficiently for the purpose of temporary cooling, the performance of which however depends on the size of the heating surface. Such a system cannot be regarded as substitute for a first-class air conditioner since its performance is too weak. Through the cooling operation of such heaters, a satisfying effect can be achieved during temporary hot spells. With the provision of cold e.g. through environmentally friendly heat pump systems, solar cooling facilities or district cooling, a comfortable room climate can be achieved. This is especially pleasant for people occupying the lower parts of rooms and in close vicinity to the cold surfaces. Finally, it minimizes the high risks of heat exposure for the elderly in need of care. The suggestion “...to hang up damp cloths indoors“ published in the 2004 guidelines for nursing staff, nursing-home management and doctors with regards to “Health risks of summer heat for the elderly in need of care“, and issued by the Health Council of the County of Baden- Württemberg, is not a good solution since the cooling effect is low whilst increasing the relative air humidity which is then experienced as extra burdening and very unpleasant. During the operation of a heating system for the purpose of cooling, condensation may develop at a temperature of under 16 °C which could be avoided through dew point detectors.

Normally, all conduits and heating surfaces are either well coated or made of non-corrosive materials as to avoid damage. During our experiments, the back of heating pipes that are not protected by paint, developed rust. Inside partition walls, on fittings as well as on heating surfaces, no rust was spotted. Neither was this the case in ceiling cut-outs, where pipe insulation is not normally used. If heating pipes are not insulated, it is recommended to cover them with vapor-resistent insulation material as is available for cooling pipes. In addition, and in order to increase both performance and cooling effect, water-circulated, mobile cooling elements with a large surface could be attached to the heating surface using a flexible hose.