EuroSun 2010 - Solar insulation with integrated air circulation system

Ing. Karl Kleebinder[1]*, Lydia Kleebinder[2] and DI Erwin Schwarzmüller[3]

[1]Ing. Kleebinder Ges.m.b.H, Pielachtalstraße 8, 3385 Markersdorf an der Pielach, Austria

[2]Ing. Kleebinder Ges.m.b.H, Pielachtalstraße 8, 3385 Markersdorf an der Pielach, Austria

[3]ecoplus Niederösterreichs Wirtschafts GmbH, Niederösterreichring 2, 3100 St. Pölten, Austria

*Ing. Karl Kleebinder, office@kleebinder.at

Overview

"Solar Insulation" Ing. Karl Kleebinder & Erwin Schwarzmüller DI Using building mass of external walls for thermal storage and heat distribution 2007 measuring project was granted by FFG. Solar insulation was mounted at 2 walls of Mr. Kleebinder´s office. 2008 patent was granted to Mr. Kleebinder convincing swisspor Ltd. and Ernstbrunner Kalktechnik Ltd. to undergo technical admission with the OIB together with Mr. Kleebinder according ÖTZ guidelines. Recently tests have proven positive on fire resistance at Ma39. "Solar Insulation" utilizes the mass of exterior walls for heat storage and heat transmission. Gains from solar hybrid collectors are transported by canals cut into insulation plates. Refurbishment projects so can realize passive-house-standard since thermal bridges, which cannot be eliminated in renovations, can be compensated by solar gains. The solar yield in solar hybrid collectors may be extended by 40% compared with standard collector, using the low temperature gains from 20°C upwards to warm the walls and storing the high temperature yield in water boilers. The system means a merge of application of insulation with heat and cold distribution and thus may convince owners of older houses to refurbishment since the steps to renovation do much lesser interfere with the habitat during renovation. It can also be applied on new buildings to increase comfort and the effectiveness of hybrid thermal solar collectors

1. Introduction

Nowadays, increasing energy prices and scarcity of fossil fuels make it more and more necessary not only to easily achieve passive house standard for new buildings, but also for existing buildings.

Therefore, it is of particular importance that the solar insulation with integrated air circulation system is predestined for constructing new passive house buildings as well as for the refurbishment of buildings up to passive house standard, while using conventional ways of construction, this means without big window areas and without the need of an alignment of the building in a southward direction.

2. Solar insulation with integrated air circulation system

2.1. Solar collectors used for the solar insulation

In the solar insulation with integrated air circulation system hybrid collectors are used to generate heat. These collectors combine the advantages of air collectors and brine collectors.

In case of small solar irradiation first of all air is heated in the collector, which due to its lower specific heat and its lower mass reacts approximately 3200 times faster than water.

In case of high solar power the heat storage capacity of air is too small to dissipate the accumulated solar gain effectively. Therefore both systems, air system and water system, are at work to ensure high efficiency of the collector.

2.2. Air flow through the solar insulation

Air is heated in the solar collector and is being transported via conducts to channels in the thermal insulation composite system of the wall, using efficiently modulating direct current ventilators.

This thermal insulation composite system distributes the hot air on the outside surface of the external walls.

Fig. 1. Allocation of the main air ducts around the building.

Via an upper main duct hot air is distributed alongside the façade whereby a second main duct alongside the bottom of the façade collects the chilled air after heat dissipation. In between the main ducts, distribution ducts are arranged, so that air may descent through these ducts from the upper warm conduct to the lower conduct, thus the thermal drive side is supporting the drive mechanism of the system.

Additionally, the oncoming flow in the lower region of the façade leads to a further cooling down of the air of the return flow of the system due to thermal bridges. The lower temperature of the return flow results in further enhancing of the solar efficiency of the system.

This is of particular advantage concerning refurbishments of buildings. Critical thermal bridges in the region of the base of a wall may be compensatory heated, which thermal bridges otherwise in case of refurbishments cannot be completely eased. This results in a further cooling down of air in the return flow of the system, the lower temperature of the return flow further enhancing the solar efficiency.

2.2.1. Clarification of the air flow in the system

The figure below in a simplified way illustrates the air flow through the ducts along the facade of a building using the solar insulation with integrated air circulation system.

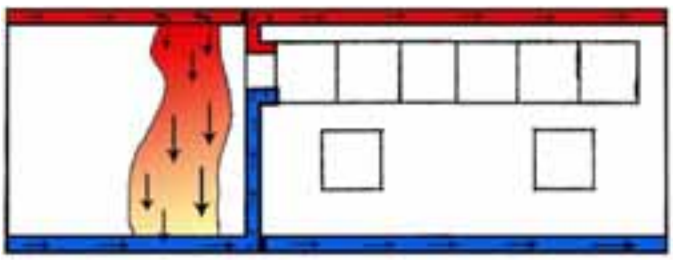

Fig. 2. Simplified illustration of the air flow through the ducts in the façade of a building

Air flows driven by a ventilator as well as ascending force and output of the loop through:

- the solar collector
- the feeding channel
- the upper main duct
- sub ducts
- the lower main duct
- the channel back to the solar collector

Both, main and sub ducts are integrated into insulating wall panels and are designed in such a way, that air in the ducts has optimal contact with the bricking, in order to efficiently transfer the heat energy to the wall.

Fig. 3. Pictures of an installation of a test wall at Ing. Kleebinder Ges.m.b.H.

The mass of the building stores heat energy and radiates this heat energy with a distinct temporal delay into the living quarters. The phase shift is especially efficient in the transition period.

During this period overheating often occurs in passive houses, especially in case of large window areas. Overheating may be avoided and the solar gain may be completely utilized through achievement of passive house standard via an installation of a solar insulation with integrated air circulation system, instead of allowing the solar gain to evaporate.

2.3. Temperature profile – example of an exterior wall

The temperature of the air between the insulation and the outer wall is used as reference temperature for the solar control. Due to the inner and outer heat transition resistance as well as due to the low heat transfer resistance of the bricking, collector temperatures up to the desired ambient temperature may be used.

Fig. 4. Calculation of the assembly of a wall using the planning software Rauwin

Thus, for the above shown assembly of a wall, at an outside temperature of -14° C and an ambient temperature of 20° C, the reference temperature is 16,8° C, above this temperature inputs may be possible. However, practical experience has shown that it is advisable to start the air circulation, which is controlled by a thermostat, at a temperature difference of some degrees, so that a high COP (Coefficient of performance) may also be obtained for the used energy of the ventilators. In this case, air circulation is already energy efficient and reasonable for heating at a collector air temperature of 20°C.

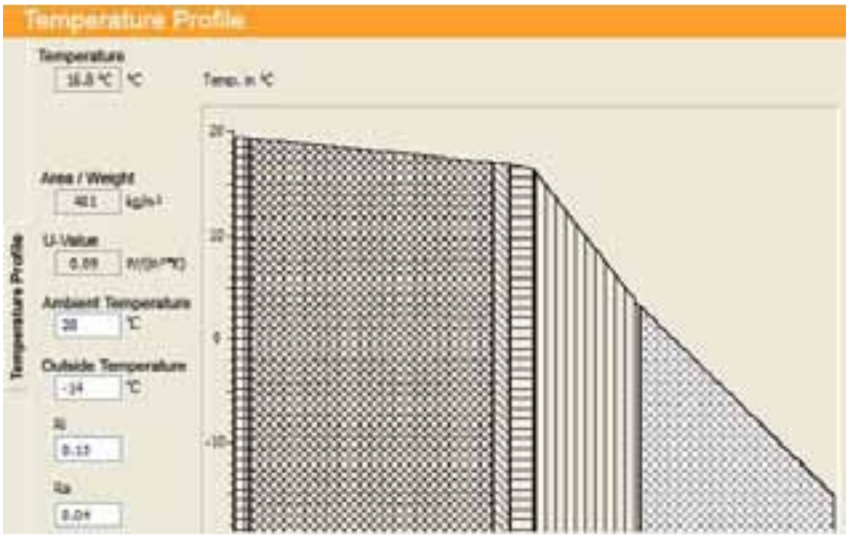

Fig. 5. Temperature profile of the wall at an outside temperature of -14° C and an ambient temperature of 20° C

For the same wall an outside temperature of 5° C and an ambient temperature of 20° C result in a reference temperature of 18,6° C for the air gap in the insulation without any usage of solar energy.

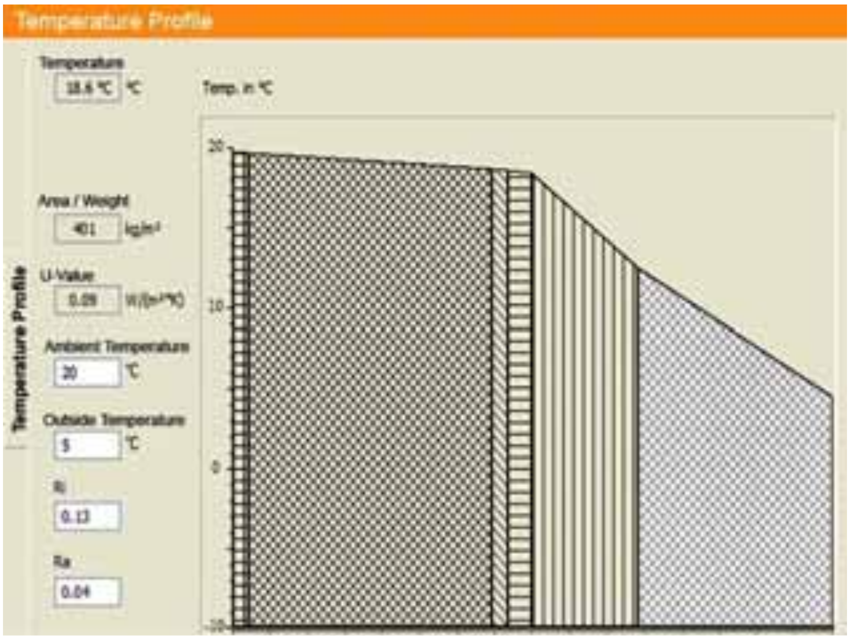

Fig. 6. Temperature profile of the wall at an outside temperature of 5° C and an ambient temperature of 20° C

Consequently, temperatures of the collector greater than 19° C may already be used for the heating of a building, thus increasing the usable gain of the collector, especially in winter.
At temperatures of the air gap in the insulation between the reference temperature and the ambient temperature, heat losses can be reduced at a temperature of the air gap of the insulation of above the ambient temperature, in this case 20°C, so that the outside surface of the outside walls does not constitute an area of cooling anymore.

In case that the temperature of air is higher than the ambient temperature, the bricking is solar loaded and radiates heat with a delay in time into the interior space. This delay in time extends the solar supply into the valuable and intensively used evening hours, whereas passive gains arising during the day through the windows are available beginning from forenoon. Heat, which cannot be directly used in the ventilation system, will be removed by a water system and is stored for buffering or for water heating.

2.4. Usage of the outside walls of a building as storage capacity

A building with 130 m² living space and two-storey proper, consisting of ground floor and first floor, has a mass of the outer wall (with 25 cm hollow bricks) of 78000kg, which is capable of storing 66300 kJ/°K. This corresponds to an equivalent of 15785 kg of water.

In case of the bricking consisting of solid bricks the corresponding values are 93000 kg or 79050 KJ/°K, which equates the storage capacity of 18821 kg water.

In order to achieve an average temperature difference of 5°K between the bricking and the inside temperature, a water reservoir with a temperature spread of 20°K would need to contain 3946 kg of water in case of a hollow brick wall, and 4705 kg of water in case of a solid brick wall, in order to be able to store the same amount of heat than the walls.

Since the mass of the bricking is already present, it is activated as “storage for free”. The distributing system for the heat is integrated into the insulating wall panel, therefore no additional system is required, and the interior plaster may act as heat emission area.

2.5. Comparison with an exclusive water system

Using the Solar insulation with integrated air circulation system, air temperatures of the collector starting form approximately 19°C may already be used for heating, whereas in case of a mere water system temperatures cannot be used until approximately 30°C are reached.

As a result of thermally quickly reacting air and the low temperatures, which can be used in the air system in combination with the water carrying system, solar gain of the system increases up to 40% compared to collectors of comparable exclusive water systems.

3. Example measurement of the solar heat insulation pilot system

Fig. 7. Diffuse irradiation in case of a 100% cloudy sky

In case of a 100% cloudy sky and ambient temperatures of 5°C to 9°C, on 13.4.2010, during the period form 9 a.m. until 6 p.m., the collector of the reference unit delivered air with a temperature between 17°C to 40°C to the bricking. The heat quantity delivered by a testing facility with a size of 11 m² of collector amounted to 5kWh (only using air mode).

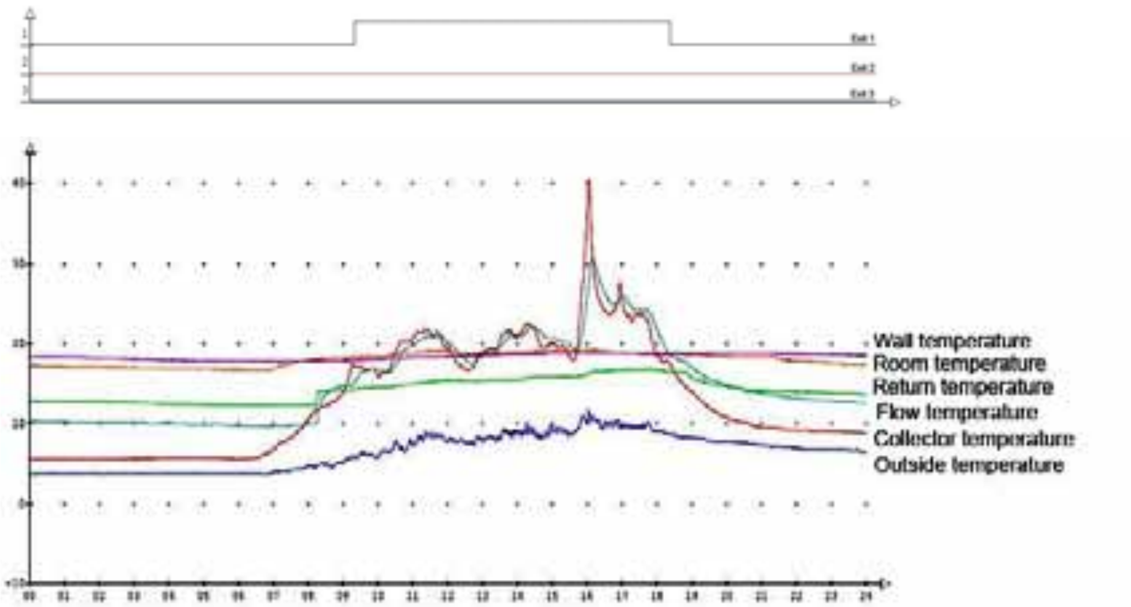

Fig. 8 Temperature measurements of the pilot wall on 13.4.2010 during 100% cloudy sky

On 4.1.2010, a sunny winter day, during the period from 10 a.m. to 5 p.m. the collector of the pilot system with a size of only 11m² collector area delivered a heat quantity of 13 kWh (only using air mode). Detailed temperature curves are shown below.

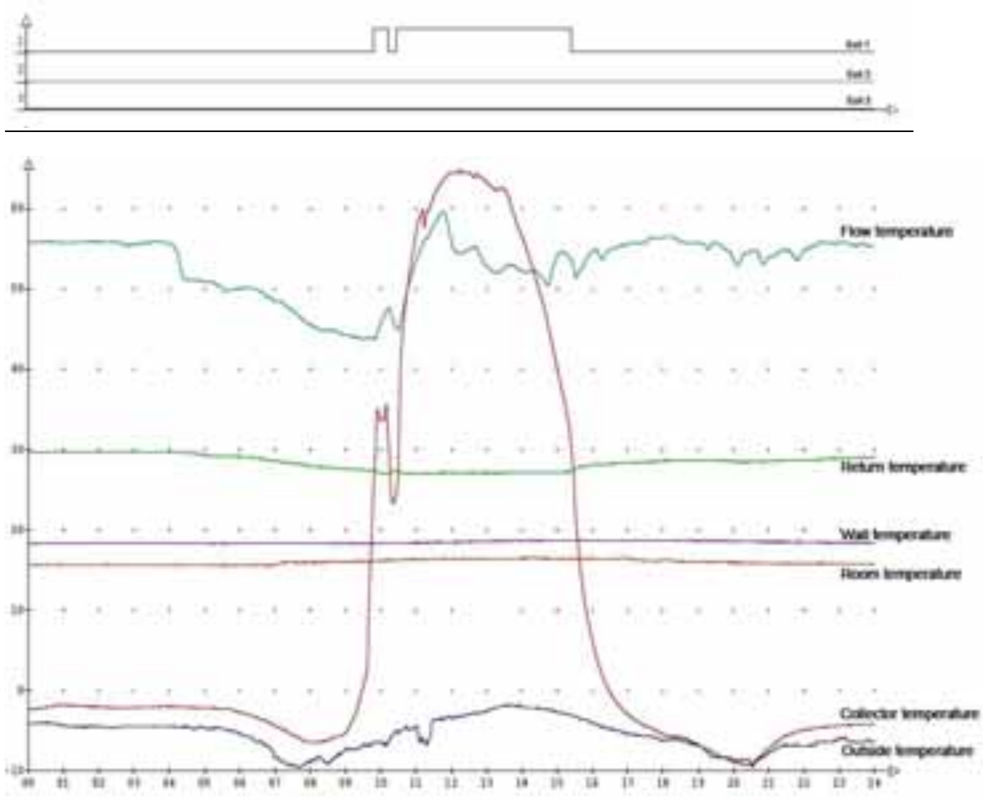

Fig. 9 Temperature measurements of the pilot wall on 4th 1.2010, a sunny winter day

4. Passive houses and the solar insulation with integrated air circulation system

Buildings with solar heat insulation are capable, even in the case of moderate window areas, to gather high solar gains

Moreover, it is possible to dispense the heat, adjusted to the heat demand, into the building. Further, due to the elapsed time for heat transmission through the bricking, a part of the solar gain is automatically shifted into the evening hours, where more heat is required.

Since windows in comparison to other parts of a building are characterised by high heat losses, a reduction of large window areas also results in a reduction of heating load and thus in a smaller loss of thermal heat. To prevent overheating, window areas have to be dimensioned carefully and means for shadowing the windows are usually necessary, whereas losses through the windows during the night and in case of a dull sky are several times higher compared to other building elements.

Fig. 10. Shadowing of windows at -11° C and clear sky

In contrast, collector areas of more than 20 m² are completely uncomplicated. Heat may be supplied between the insulation and the bricking, controlled by temperature. When the preferred temperature in the building is reached (e.g. > 25°C), the air circuit is switched off.

Further advantages of collectors compared to the direct use of solar energy through windows are that collectors may be positioned in an optimized way in regions, which are not covered by shadows, and the possibility to achieve an optimal g-value due to solar glazing and a selective coating. Windows are frequently shaded, due to their surrounding (trees, neighbouring buildings) as well as due to their installation in the building, since the windows have to be installed with respect to the floor plan of the building and the function of the rooms.

3-glass panes of passive house windows have g-values in an exemplary region of 0,47 to 0,7, far below the g-value of a solar collector (g > 0,85), whereupon selective collectors additionally obstruct their outwardly directed radiation (ε<0,25). The vertical installation of the windows reduces the solar gain being usable during the heating period even in the south by more than 15%, so that after subtraction of losses due to contamination and shadowing of 100% solar radiation only 35% reach the interior of the building. Obviously, by the use of the solar heat insulation it becomes possible to reduce the window areas to the areas necessary for illumination and prospect, and thermal losses of the building may be reduced. The main supply with solar heat takes place by a solar collector with high solar efficiency.

5. Conclusion

The solar heat insulation expands the application of solar use for newly built houses as well as for refurbishment and thus may significantly contribute to the solution of structural-physical problem areas. The integration of the heat (cold) distribution into the insulation combines civil engineering and building services and enables the refurbishment up to the point of passive house standard with only small inconveniences for the inhabitants. Moreover the future, further developments with respect to a solar insulation with integrated air insulation system may guarantee the required minimum air change in buildings.

In a nut shell the solar insulation describes the integration of solar thermal use into a thermal insulation composite system. Advantages of the solar heat insulation are the better controllability of the solar gains, the phase shift of the solar gain, the use of the storage mass of the building and in case of a refurbishment of the building, the possible compensation of otherwise critical thermal bridges in the region of the base of a wall. Thus, even in case of refurbishment it becomes possible to reach passive house standard.