

HEAT EXCHANGER PANEL FOR CONTROLLING THE TEMPERATURE OF BUILDING ROOMS

5 The invention relates to a heat exchanger panel for temperature control of building rooms and a method for temperature control of building rooms using such a heat exchanger panel.

It is known, for the purpose of temperature control in buildings - i.e., for heating and cooling purposes - to heat or cool a component of the building, e.g., by means of a heated or cooled pipe
10 coil. In this way, the component can release heat to the room air and surrounding surfaces through radiative exchange or absorb heat from the room air, surrounding surfaces, and heat loads within the room, thereby influencing the indoor climate. Common components include ceiling panels, wall panels, or floor heating systems equipped with a water-filled pipe coil or an electrically powered heating wire. This can be installed directly during the construction of the building or
15 retrofitted in an existing building.

For example, DE 10 2008 053 192 A1 relates to a solar collector with a cooling function, whereby the solar collector can, on the one hand, convert incident solar radiation into heat and, on the other hand, dissipate thermal energy, for example from a building. To this end, the solar collector
20 comprises a device through which a first heat transfer fluid can flow, which is in contact with an absorber. By means of the absorber, incident solar radiation is converted into heat and removed by the first heat transfer fluid. The solar collector also comprises a device through which a second heat transfer fluid can flow, which leads to an outer surface. The second heat transfer fluid carries heat to the outer surface, where it is released into the environment.

25 Furthermore, DE 20 2008 014 419 U1 discloses a solar-powered collective collector for the simultaneous generation of electrical power and thermal heat, as well as a solar cooling unit. The collective collector comprises a light-entry pane, at least one photovoltaic cell, at least one light-absorbing layer, and at least one fluid-filled pipe, wherein the fluid is heated. Sunlight passes
30 through the light-entry pane and reaches the light-absorbing layer via an opening in the photovoltaic cell; the light-absorbing layer absorbs the sunlight and is thereby heated. The light-absorbing layer is in thermal contact with the pipe, causing the fluid in the pipe to be heated. The collective collector is particularly suitable for use with a refrigeration machine.

CN 107606824 A discloses an evaporator and an air conditioning refrigeration system. The evaporator comprises a heat exchanger element and a heat-resistant, permeable plate, wherein the heat-resistant, permeable plate is arranged on at least one side of the heat exchanger element at its surface and is in contact with ambient air. The heat-resistant, permeable plate is thermally insulating and at least partially permeable to heat radiation. The material of the heat-resistant, permeable plate may be polyethylene. The heat exchanger element further comprises a tube through which a cooling medium can be passed. By means of the evaporator, heat can thus be removed from a room in which the heat radiation generated therein is absorbed.

10 Based on the prior art, the present invention is thus directed to the task of providing a heat exchanger panel for temperature control of building rooms, which controls the temperature of the building rooms in an energy-efficient manner and, in particular, exhibits a good cooling effect with a very low convection component.

15 Another task of the present invention is to provide a heat exchanger panel for temperature control in building rooms that exhibits high radiant heat exchange across a wide temperature range.

Another task of the present invention is to provide a heat exchanger panel for temperature control in building rooms that virtually eliminates condensation on the heat exchanger panel.

20 Furthermore, it is a task of the present invention to provide a heat exchanger panel for temperature control of building rooms that exhibits high mechanical stability, with the heat radiation exchange being hardly affected.

25 In addition, a task of the present invention is to provide a heat exchanger panel for temperature control of building rooms that is visually appealing without significantly affecting heat radiation exchange.

One or more of these tasks are solved by the features of the independent patent claim.

30 Advantageous embodiments are described in the dependent claims.

According to a first aspect of the invention, a heat exchanger panel for temperature control of building rooms is provided. The heat exchanger panel comprises a heat exchanger, which has a medium line for conducting a heat exchanger medium, and a heat exchanger wall which is in thermal contact with the medium line. The heat exchanger wall has a boundary surface facing the

building room, the temperature of which can be brought to a temperature which is lower than a heat load or higher than a cooling load. The heat exchanger panel further comprises a layer of polymer material disposed on the boundary surface of the heat exchanger, wherein the layer comprises gas bubbles or gas chambers such that it is at least partially transparent to heat radiation.

- 5 The heat exchanger panel is distinguished in that the layer of polymer material has a transparency of no more than 30% in a wavelength range of heat radiation between 9 μm and 11 μm .

Heat radiation is electromagnetic radiation in the infrared wavelength range that penetrates the layer of polymer material at least partially. The wavelength range of heat radiation (infrared
10 radiation) typically extends from 780 nm to 1 mm. For the spectral range from 4 μm to 12 μm , the term “room-temperature radiation” may also be used. This spectral range contains a large portion of the heat radiation energy emitted by a blackbody at approximately room temperature. If the heat exchanger panel is to be used for cooling in a warmer climate, this spectral range may be slightly shifted. Similarly, shorter wavelengths may occur if the building room contains specific heat
15 sources, such as electrical appliances. The spectral range from approximately 2 μm to approximately 100 μm contains nearly all of the heat radiation energy emitted by a blackbody at approximately room temperature.

The wavelength range between 9 μm and 11 μm encompasses the peak of room-temperature
20 radiation, which is why this range is also the most important for assessing transparency.

The layer of polymer material exhibits a transparency of no more than 30% in the wavelength range of heat radiation between 9 μm and 11 μm . While this means that the layer exhibits a transparency of no more than 30% in this wavelength range, the layer also exhibits a certain degree
25 of transparency in the remaining wavelength range between 780 nm and 1 mm, particularly in the range between 2 μm and 100 μm . This transparency may also exceed 30% at individual wavelengths; however, on average across the wavelength range from 780 nm to 1 mm, particularly between 2 μm and 100 μm , the layer exhibits a transparency of no more than 30%. As a rule, the layer even exhibits significantly higher absorption at certain specific wavelengths, so that
30 transparency is lower at those specific wavelengths.

The layer of polymer material exhibits a transparency of no more than 30% with respect to heat radiation in the wavelength range between 9 μm and 11 μm across the entire local average of the layer’s volume. For the remaining wavelengths of heat radiation, the layer of polymer material
35 generally exhibits the same property.

Such a layer is preferably a foam layer. A foam layer is not homogeneous, i.e., the amount of material present varies at different locations in the cross-section. A transparency of the layer of polymer material of no more than 30% with respect to heat radiation in a wavelength range between 9 μm and 11 μm means that, when viewed over the entire volume of the layer, on average no more than 30% of the total heat radiation between 9 μm and 11 μm striking a surface of the layer facing the building room reaches the boundary surface. At individual points within the layer, transparency may exceed 30%, though typically it is only slightly more than 30%. 70% of the heat radiation between 9 μm and 11 μm is absorbed or, to a small extent, reflected across the entire volume of the layer. Depending on the choice of material and solid angle, a proportion of 1% to 15% of the heat radiation between 9 μm and 11 μm is reflected. Polymers typically exhibit a physically unavoidable reflection in the range of 5% to 15%. For the remaining wavelengths of heat radiation, the layer of polymer material can exhibit the same properties.

The transparency of the layer of polymer material is determined using FTIR spectroscopy (Fourier-transform infrared spectroscopy), a type of infrared spectroscopy, in a dedicated FTIR spectrometer. A sample of the layer is placed in the spectrometer in the same form as it is formed on the heat exchanger panel. The layer is inserted into the spectrometer without any modification, such as that which would result from pressing the layer. In the spectrometer, the layer is irradiated with infrared radiation at wavelengths of 9 μm to 11 μm perpendicular (at a 90° angle) to the surface of the foam layer. The intensity of the radiation (energy density) after passing through the layer is measured and compared with the intensity of the incident radiation. A transparency of the layer of polymer material of no more than 30% in a wavelength range of heat radiation between 9 μm and 11 μm means that the measured intensity of the radiation in the range of 9 μm to 11 μm after passing through the layer is no more than 30% of the intensity of the incident radiation. This measurement method can be performed, for example, using the FTIR spectrometer INVENIO® from Bruker.

Unless otherwise specified, the term “heat radiation” in the following refers to the wavelength range between 2 μm and 100 μm .

The layer consisting of polymer material contains gas bubbles or gas chambers. The gas filling of the gas bubbles or gas chambers is largely permeable to heat radiation. The gas bubbles or gas chambers are preferably filled with air. The gas filling preferably equalizes the pressure conditions

within the layer. The gas filling of the layer thus preferably has a pressure level nearly identical to that of the surrounding air. The layer is hereinafter referred to as the “foam layer.”

The foam layer can be regarded as a barrier against air and water vapor from the room, which cannot pass through the foam layer to the boundary surface. As a result, no convective heat exchange can take place between the air and the boundary surface.

The foam layer is connected to the heat exchanger at the boundary surface on one side and has a free surface on the other side, which is hereinafter referred to as the “surface of the foam layer” or simply as the “surface.”

The term “building room” refers to both enclosed and open rooms. An enclosed room is a room that is closed on all sides. An open room includes all types of rooms that are open on at least one side. This can be, for example, a bus shelter or a covered outdoor area. In the following, all such rooms are referred to as “room.”

The heat exchanger panel may be designed to cool a room (cooling scenario). In this case, there is a heat load in the room. The heat exchanger medium in the medium line is then a cooling medium. In the case of a heat load in the room (at a relative humidity of 60%), the room temperature is typically around 20°C to 30°C, and the temperature of the heat exchanger medium is typically around 6°C to 20°C.

The heat exchanger panel can also be designed to heat a room (heating scenario). In this case, there is a cooling load in the room. In this case, the heat exchanger medium is a heating medium. The room temperature is typically about 10°C in the event of a cooling load in the room, and the temperature of the heat exchanger medium is typically about 35°C to 50°C.

The foam layer is designed such that it exhibits a transparency of no more than 30% in a wavelength range of heat radiation between 9 μm and 11 μm .

In principle, for the heat exchanger panel to function, transparency should be as high as possible so that heat radiation can be absorbed as completely as possible at the temperature-controlled boundary surface. However, high transparency - for example, more than 60% - requires that very little polymer material be applied to the boundary surface. This necessitates a very thin or very delicate foam layer. A thin foam layer provides only minimal thermal insulation against thermal

conduction, so that the surface of the foam layer quickly approaches the temperature of the boundary surface.

The inventor has discovered that a maximum transparency of 10% is already sufficient, since then approximately 10% of the heat radiation strikes the boundary surface directly, but a further significant portion of the heat radiation in the vicinity of the boundary surface is absorbed by the temperature-controlled foam layer through the material thickness itself, and the heat is transferred to the boundary surface via thermal conduction.

In addition, lower transparency allows for the use of more polymer material or a thicker foam layer. A foam layer with a certain minimum thickness of, for example, 0.5 cm to 1.5 cm provides good thermal insulation, so that the surface of the foam layer can be kept above the dew point even if the boundary surface is kept below the dew point.

It has been shown that such a foam layer with a maximum transparency of no more than 40% or no more than 30% or no more than 20%, in a wavelength range between 9 μm and 11 μm , provides sufficient thermal insulation to achieve the desired functions of dissipating heat introduced by heat radiation and insulating the surface of the foam layer, so that the surface temperature remains above the dew point.

To elaborate, a thicker foam layer allows more heat to be transferred from the room into the foam layer, where it is both stored and dissipated. This heat input occurs, on the one hand, through thermal conduction near the surface of the foam layer, with the heat being transferred from the room air to the surface via convection. On the other hand, the heat input occurs throughout the entire volume of the foam layer due to the foam layer's increased absorptive capacity (resulting from the low transparency of the total layer thickness, but significant transparency in the heat radiation spectrum across a portion of the material's thickness). The heat input into the foam layer exceeds the heat flow from the (constantly) cool boundary surface to the surface and effectively prevents the surface from cooling below the dew point temperature of the room air up to a defined point. According to the principle, this point is close to the average room temperature.

A surface of the foam layer with a temperature below the average room temperature would lead to condensation forming on the surface due to the room air once the dew point temperature of the room air is reached, which must be avoided at all costs. This effect is also supported by heat gains from passing warm room air (in the typical application of a suspended ceiling panel or wall panel).

Warm room air rises and encounters the slightly cooler surface. Consequently, the room air cools slightly, but at the same time warms the surface and goes down again.

At the same time, a heat flux acts on the boundary surface via heat radiation from the room surfaces visible from the surface, causing the boundary surface to strive for an equilibrium temperature corresponding to the average radiation temperature.

If the foam layer is too thin, a heat flow from the (constantly) cool boundary surface to the surface of the foam layer exceeds the heat from the room contained within the foam layer, leading to a cool surface and thus to condensation.

To achieve a transparency of the foam layer, particularly across the entire layer thickness, of 30% in a wavelength range between 9 μm and 11 μm , the layer must already be very thin. With a constant density of gas bubbles or gas chambers in the foam layer, the thinner the layer, the higher the transparency. However, if the layer is formed so thin that it exhibits a transparency of over 30%, it becomes unstable.

On the other hand, the transparency of the foam layer can be increased to over 30%, and in particular to over 50%, by incorporating larger gas bubbles or gas chambers into the foam layer - while maintaining the same layer thickness and number of gas bubbles or gas chambers - or by making the walls of the gas bubbles very thin. However, this then results in there being little material in the foam layer, which makes the foam layer very unstable. If there is little material in the layer to absorb heat in the form of heat radiation and through convection from the ambient air, then the heat flow from the (constantly) cool boundary surface once again exceeds the heat present in the foam layer.

The inventor has recognized that, for a foam layer with a transparency of no more than 30% in a wavelength range between 9 μm and 11 μm , an equilibrium is established that allows for the most effective possible heat transfer from the room to the boundary surface (via heat radiation and thermal conduction through the foam layer), while simultaneously allowing sufficient heat to be absorbed by the foam layer so that no (or only a very small) heat flux from the boundary surface reaches the surface of the foam layer.

In the case of a cooling load in the room, an equilibrium is established in the same manner for a foam layer with a transparency of no more than 30% in a wavelength range between 9 μm and 11

μm, where heat (via heat radiation through the foam layer) is emitted from the boundary surface into the room, while at the same time no heat flow from the boundary surface reaches the surface of the foam layer, thereby keeping the foam layer cool enough at the surface so that the loss of convective heat at the surface is kept low. This convective heat would be completely lost, especially when heating outdoor spaces, as it is carried away by moving air in the outdoor area.

Only a small portion of the heat is lost through convective heat transfer. This is the portion of heat radiation from the boundary surface that is absorbed by the foam layer in a region near the surface of the foam layer and then reaches the surface via thermal conduction.

The radiant heat generated by the heat exchanger panel ensures relatively low-loss heating. This means that the temperature of the heat exchanger medium can be relatively low, yet effective heating of an outdoor space is still possible. Since the temperature level of the heat exchanger medium can be relatively low, heat pumps can be used to heat the medium. The heat exchanger panel thus offers the possibility of energy-efficient heating even in outdoor areas.

Since the foam layer allows only limited thermal conduction from the tempered boundary surface to the surface of the foam layer and prevents convective heat exchange between the boundary surface and the room air, a large temperature difference can form between the boundary surface and the surface. Thus, in the event of a heat load in the room, the boundary surface can be cooled down to a temperature below the dew point, while the surface maintains a temperature above the dew point temperature of the room air, resulting in effective cooling through the absorption of heat radiation from room surfaces or heat sources. Furthermore, the insulating effect of the foam layer from the boundary surface toward the surface allows the boundary surface to be cooled down particularly quickly.

At the same time, preventing convective heat exchange between the boundary surface and the room air ensures that no moisture from the room air can condense on the boundary surface, even though the boundary surface has a radiant temperature below the dew point.

When the heat exchanger panel is arranged over a large area in a room, the room can be cooled very efficiently and quickly, while still preventing moisture from condensing on the boundary surface. This prevents the room or the surface of the foam layer or the heat exchanger panel from becoming contaminated, or equipment or furnishings from being damaged, people from being

inconvenienced, structural damage from occurring, and/or the indoor climate from being negatively affected.

5 In the event of a cooling load in the room, the boundary surface can be heated to a high temperature and can be heated up quickly.

10 By placing the foam layer, which is permeable to heat radiation, on the cooled or heated boundary surface, the actual surface temperature of the foam layer (which essentially corresponds to the average room temperature) is decoupled from the radiation temperature at the surface of the foam layer. The radiation temperature at the surface of the foam layer can therefore be lower than the real temperature of the surface in the case of cooling. The radiation temperature at the surface corresponds to a value that depends on the transparency, thermal conductivity, and surface texture of the foam layer and, as transparency increases, approaches the radiation temperature of the boundary surface more and more. A higher thermal conductivity of the foam layer causes the material surface temperature to approach that of the boundary surface. The surface texture - for example, an increase in surface area due to a rough surface - can influence heat transfer resulting from convective and radiative conditions. An example of this would be a deliberately grooved or uneven structure.

20 The additional potential temperature difference results in a higher power density and fewer convective losses in the event of a heat load or a cooling load in the room, compared to a exposed boundary surface. An exposed boundary surface refers to direct contact between the room air and the boundary surface. Consequently, the foam layer increases the efficiency of heat radiation. In particular, the additional potential temperature difference between the average flow temperature ((flow temperature + return temperature)/2) results in a higher power density over a wide temperature range than with an exposed boundary surface that is in direct contact with the room air.

30 While limiting the dew point of the boundary surface restricts the temperature difference and consequently the absorption capacity, a dew-point-independent boundary surface can be operated constantly with a high temperature difference and low radiation temperatures.

35 The inventor has recognized, on the one hand, that for a foam layer, a transparency of more than 30% in a wavelength range between 9 μm and 11 μm is not necessary to achieve the desired thermal properties, and, on the other hand, that a mechanically stable foam layer capable of long-

term operation is possible with a transparency of no more than 30% in a wavelength range between 9 μm and 11 μm .

The foam layer may be firmly bonded to the boundary surface. The foam layer may also be a body that is applied to the boundary surface and bonded thereto. It is also possible for the foam layer to be merely placed on the boundary surface and clamped to it. For this purpose, a circumferential seal may be provided by bonding or a dry seal on the boundary surface to which the foam layer is applied. In this way, the foam layer can be separated from the boundary surface again at a later time as needed.

Edgings may be provided on the sides of the heat exchanger panel. These edgings may be firmly connected to the heat exchanger panel and/or to the foam layer. In the case of a fixed connection to the heat exchanger panel and to the foam layer, the foam layer can thus be additionally secured. The edgings can therefore serve aesthetic and/or structural purposes.

The foam layer may also be designed to completely surround the heat exchanger's medium lines. In this case, the medium lines run within the foam layer. This ensures better heat transfer. In this case, the foam layer is not located at the boundary surface but on a surface of the ceiling or wall panel. A thermally conductive layer may nevertheless be provided, which connects the medium lines within the foam layer to one another and thus forms a large surface area.

The layer of polymer material may have a transparency of no more than 25%, 20%, 15%, 10%, or 5%, in the wavelength range of heat radiation between 9 μm and 11 μm .

In a wavelength range of heat radiation between about 2 μm and about 20 μm or between about 2 μm and about 100 μm , the layer of polymer material may have a transparency of no more than 30%, no more than 25%, no more than 20%, no more than 15%, or no more than 10% or not more than 5%.

The layer of polymer material may have a thickness of at least 2 mm, at least 3 mm, at least 4 mm, at least 5 mm, at least 6 mm, at least 7 mm, or at least 8 mm, and/or a thickness of at most 150 mm, at most 75 mm, at most 50 mm, at most 28 mm, at most 27 mm, at most 26 mm, at most 25 mm, at most 24 mm, at most 23 mm, or at most 22 mm. In particular, the layer may have a thickness of 10 mm to 14 mm.

The thickness of the foam layer may be adapted to the specific requirements based on the ambient climate and the operating temperature of the boundary surface.

5 The polymer material of the layer may be formed from a polyolefin, preferably polyethylene or polypropylene, or a mixture thereof.

10 The polymer material may be formed from any combination of polyolefins. Furthermore, the polymer material may be provided with various additives, such as flame retardants, inhibitors, UV protection, or special reflective or absorptive particles, or heat transport layers. The surface of the foam layer may be coated on the front and/or back.

15 The foam layer can have a transmission of 20% to 80% for radiation with a wavelength in the range of 4 μm to 12 μm at a thickness between 2 mm and 20 mm. Therefore, these materials are suitable for forming the foam layer. Preferably, a flame-retardant, closed-cell polyethylene foam with a low density is used. Alternatively, polypropylene, or a copolymer of two or more polymers, or a polyolefin foam is used.

20 The layer of polymer material may consist of a foam, particularly a closed-cell foam, or a bubble film or hollow-cell film. The layer may completely cover the boundary surface.

25 Foams and bubble films are suitable materials for the foam layer because they have gas-filled cells, which give the foam layer a certain degree of transparency to heat radiation. At the same time, the foam layer can thus be formed so as to be relatively light-weight, so that the total weight of the heat exchanger panel is hardly increased. Since the gas in the cells usually acts as a good thermal insulator, the remaining material of the foam layer preferably exhibits properties that contribute to thermal conduction.

30 The material of the foam layer may be blended with materials that exhibit high absorption of heat radiation. This can improve the heat input from heat radiation into the material. Additionally or alternatively, the material of the foam layer may be blended with materials that exhibit high thermal conductivity. This increases the heat input from convective heat in the room and the thermal conductivity of the foam layer.

35 The foam layer is preferably designed and positioned at the boundary surface in such a way that moisture ingress at the boundary surface is prevented. Nevertheless, capillary channels may be

provided in the foam layer to drain moisture toward the room. The capillary channels run as directly as possible from the boundary surface toward the room and carry the accumulated moisture back into the room. This ensures the long-term functionality of the heat exchanger panel.

- 5 The capillary channels may be made of the same material as the foam layer or of another capillary-active material.

It may be provided that the foam layer is additionally arranged circumferentially around the sides of the heat exchanger panel. In this case, the foam layer may have a different thickness in the
10 lateral areas of the heat exchanger panel than on the side facing the room.

The heat exchanger comprises medium lines through which a cold or hot heat exchanger medium (preferably a fluid) can flow. The heat exchanger is a body that encompasses these medium lines or in which these medium lines are embedded, and within which heat is distributed primarily by
15 thermal conduction. In extreme cases, the heat exchanger may consist solely of the medium lines. As a rule, however, the heat exchanger comprises a body in which the medium lines are embedded and in which heat is distributed predominantly by thermal conduction rather than by heat radiation.

In the simplest case, the heat exchanger may consist solely of a pipe carrying a hot or cold medium
20 and the associated foam layer. The supporting structure in the ceiling or wall area can then be provided, for example, by pipe clamps or a tensioning structure.

Heat radiation is generally emitted from the boundary surface both into the surrounding space and into the interior of the heat exchanger. However, heat radiation can only propagate inside the heat
25 exchanger if the heat exchanger is made of a material with low density or high transparency, particularly in the infrared spectrum. The higher the density, the lower the propagation of heat via heat radiation and the greater the transfer via thermal conduction.

The heat exchanger may comprise at least one straight or meandering tube and/or be a plate heat
30 exchanger.

The heat exchanger may also be a freely formed body with conduits that deviates geometrically from a flat plane, or may be formed directly from a conduit.

In a preferred embodiment of the heat exchanger panel, the heat exchanger comprises at least two parallel straight tubes connected to one another by several thinner tubes that also run parallel. The heat exchanger may also be a pipe system with capillary tubes or a capillary tube mat. In this case, the pipes are preferably integrated into a ceiling or wall panel so that the material of the ceiling or wall panel fills the interstices between the pipes. However, the pipes may also be mounted exposed on the ceiling or wall panel.

The surface of the pipes is particularly relevant for room temperature control. These surfaces can be smooth or rough to influence their absorption or reflection properties. The surfaces may also contain or consist of a metal or an alloy. Due to the high thermal conductivity and/or high heat capacity of the surfaces and high absorption in the radiation range of heat radiation from 2 μm to 20 μm or 2 μm to 100 μm wavelength, the performance of the device according to the invention can be increased. Conversely, the response behavior of the heat exchanger panel can be specifically influenced by a low or high heat capacity of the surfaces, or by additionally incorporated or attached phase-change materials (PCM).

The heat exchanger and/or the ceiling or wall panel may be made of or consist of the same material as the foam layer. This reduces the variety of materials and improves recyclability. Thus, the heat exchanger may also be a capillary tube mat made entirely of a polymer material.

It may be provided that the material of the heat exchanger and/or of the ceiling or wall panel is mixed with highly radiation-absorbing particles, such as carbon particles. These particles absorb heat radiation coming from the room as well as the radiation emitted by the heat exchanger itself. The particles absorb all heat radiation very quickly, preventing it from penetrating deeply into the material. The absorbed heat radiation is converted into heat and contributes to the heating of the heat exchanger through thermal conduction. It may also be provided that the foam layer is mixed with such radiation-absorbing particles.

Any particles with good absorptive capacity can be used as radiation-absorbing particles. These can be, for example, polymer or metal particles. However, metals generally exhibit a high reflectivity for IR radiation. If the heat exchanger and/or the ceiling or wall panel, as well as the foam layer, are made of a polymer material, carbon particles or particles of a radiation-absorbing carbon compound are suitable for this purpose. From a chemical perspective, polymer materials are also carbon compounds, which keeps the variety of materials limited and maintains high recyclability.

An additional thermally conductive layer may be provided between the heat exchanger and the foam layer.

- 5 The thermally conductive layer can be inserted between the heat exchanger and the foam layer in such a way that the surfaces of the individual lines of the heat exchanger are additionally thermally conductively connected to one another. The thermally conductive layer is, for example, a layer of metal. In particular, the thermally conductive layer may be an optically functional layer applied by a printing process or other coating methods. This creates a large total surface area of the heat
10 exchanger that exhibits uniform temperature distribution. In the case of a heating load in the room, a large cooling surface is thus formed that absorbs heat radiation across its entire surface and conducts it to the pipes. In the case of a cooling load in the room, however, a large heating surface is formed that emits heat radiation over a large area into the room.
- 15 A moisture-wicking layer, such as a capillary-active nonwoven fabric, may be provided between the heat exchanger and the foam layer.

- Instead of or in addition to the capillary channels in the foam layer, a moisture-wicking layer may be provided at the boundary surface. This moisture-wicking layer is preferably a capillary-active
20 nonwoven fabric. The nonwoven fabric is preferably made of highly absorbent, biologically resistant synthetic fibers. The nonwoven fabric is intended to buffer any moisture that may accumulate and to divert it to a region of the nonwoven fabric where it can dry, for example, in the ambient air.

- 25 Electronic components, such as sensors, semiconductors, LEDs, and/or other active or passive components, or thermal storage materials, may be arranged between the heat exchanger and the foam layer.

- The components may also be electrothermal components, such as Peltier elements. In some
30 embodiments, a PCM material may also be incorporated for thermal buffering.

Electronic components such as LEDs may be provided for decorative and technical purposes. Thus, the heat exchanger panel can serve not only to regulate the temperature of a room but also, in conjunction with lighting elements, contribute to the room's visual design and workplace

lighting. In warehouses or laboratories, where a constant temperature and/or constant humidity are very important, sensors may be provided to continuously monitor these values.

5 The foam layer may be applied to a portion of the boundary surface, leaving part of the boundary surface exposed to allow moisture to condense on it.

10 In this configuration, the heat exchanger panel enables not only the cooling of a room but also the dehumidification of the room. Since the boundary surface for cooling the room is cooled to a temperature below the dew point according to the invention, significant condensation of moisture from the room air occurs on the exposed sections. This condensate is preferably drained by a capillary-active fleece applied to the boundary surface into an outer edge area of the heat exchanger panel and collected there. A collection channel is preferably provided in the edge area to collect and drain the moisture. Dehumidification of the room can thus be achieved in a simple manner as well. This is also accomplished with lower airflow than in typical air conditioning units, yet offers
15 the advantage of system integration.

On a side of the heat exchanger facing away from the building room to be temperature-controlled, a heat-insulating and/or sound-absorbing layer and/or a layer impermeable to water vapor diffusion may be provided.

20 The heat-insulating layer can, for example, reduce energy losses from the room to the outside or to spaces and surfaces that do not need to be heated.

The sound-absorbing layer reduces the sound level in the room by absorbing sound waves. This
25 improves, among other things, speech intelligibility in rooms. The sound-absorbing layer is, for example, an acoustic foam and is preferably made of the same material as the vapor-impermeable thermal insulation material. The acoustic foam has a more open-celled surface compared to the thermal insulation material.

30 The layer that is diffusion-tight to water vapor prevents moisture from entering the ceiling and/or wall of the room or the surface of the heat exchanger.

The heat exchanger panel can be an integral part of a building, such as a ceiling or wall constructed using solid construction methods. If the heat exchanger panel is integrated into a ceiling panel, a
35 suspended ceiling panel, or a wall panel, it can be retrofitted into an existing building along with

the panels. Installing such panels creates a large surface area for the exchange of heat radiation, which is used to regulate the temperature of a room. This allows for rapid cooling or heating, while also ensuring that the room is heated or cooled in a comfortable manner, as no air currents are generated, unlike with a conventional air conditioning system. The material of the panels is preferably a water vapor-diffusion-tight thermal insulation material.

When the heat exchanger panel is in operation, the boundary surface facing the room is brought to a temperature lower than the heat load (cooling scenario) or higher than the cooling load (heating scenario). This can be achieved, for example, using a refrigerant or a heating medium. The refrigerant or the heating medium can be, for example, water, which is cooled or heated by means of a heat pump. In this way, either the temperature of the boundary surface can be lowered to extract heat from the heat load, or the temperature of the boundary surface can be raised to supply heat to the cooling load. Using the foam layer, these effects can thus be achieved in a simple and particularly cost-effective manner.

The heat load can be, for example, solar radiation or heat generated by electrical devices or people in the room. Typically, the warm room surfaces emit more heat radiation than the cooling surface of the heat exchanger panel, resulting in energy transfer from the warm room surfaces to the cooled boundary surface. The (infrared) heat radiation emitted by the heat load is absorbed by the cold boundary surface and the foam layer and is removed from the room by the refrigerant.

The cooling load is typically caused by cool room surfaces, cool surfaces of objects in the room, or people who have a lower radiant temperature than the radiation temperature of surface of the heat exchanger panel. Conversely, the room surfaces then absorb more heat from the warm boundary surface than they release. The heating medium heats the boundary surface via thermal conduction, from which the (infrared) heat radiation is then emitted into the room. Heat is additionally supplied to the room via the foam layer, which conducts it to the surface.

According to a second aspect of the invention, a heat exchanger panel is provided for temperature control of building rooms. The heat exchanger panel comprises a heat exchanger having a medium line for conducting a heat exchanger medium, and a heat exchanger wall which is in thermal contact with the medium line. The heat exchanger wall has a boundary surface facing the building room to be temperature-controlled, which can be brought to a lower temperature relative to a heat load or to a higher temperature relative to a cooling load. The heat exchanger panel further comprises a layer of polymer material disposed on the boundary surface of the heat exchanger,

wherein the layer comprises gas bubbles or gas chambers such that it is at least partially transparent to heat radiation. In addition, the heat exchanger panel comprises a cover layer which is arranged on the layer of polymer material and at least partially transparent to heat radiation.

- 5 The heat exchanger panel of the first aspect of the invention corresponds to the heat exchanger panel of the second aspect of the invention, except for the cover layer.

In the second aspect of the invention as well, the layer of polymer material is referred to as a “foam layer,” the free surface of the foam layer as a “surface,” and the building room as a “room.”

- 10 The cover layer may be a perforated support structure having a plurality of through-holes, such that it is substantially permeable to heat radiation.

- 15 The perforated support structure can be a substantially plate-shaped body with a plurality of through-holes.

- 20 The perforated support structure is a structure open to air. Air can reach the foam layer through the through-holes of the perforated support structure with virtually no obstruction. The same applies to heat radiation. The number and size of the through-holes can be selected such that the perforated support structure as a whole has the largest possible opening width, allowing heat radiation to pass through for the most part.

- 25 The perforated support structure provides the heat exchanger with mechanical stability. At the same time, the perforated support structure protects the heat exchanger on the side facing the room. This could include, for example, impacts against the heat exchanger. Such impacts would quickly lead to damage if they struck the foam layer directly. Due to the maximum possible opening width of the perforated support structure, it can have a low dead weight but high stability.

- 30 Due to the mechanical stability provided by the perforated support structure, the other structures of the heat exchanger can in turn be designed to be less stable, thereby saving weight and material and reducing costs.

In addition to mechanical stability, the perforated support structure allows the heat exchanger to be designed with an aesthetically pleasing appearance. Thus, the perforated support structure

enables the creation of a fully functional heat exchanger that, depending on the design of the perforated support structure, can be either discreet or visually enhance a room.

Thus, the perforated support structure enables the provision of a lightweight, functional, yet mechanically stable heat exchanger in which the heat exchange properties are hardly affected by the perforated support structure and which, at the same time, can feature a visually appealing design thanks to the perforated support structure.

The perforated support structure may be connected to the foam layer in a surface-mounted manner.

The perforated support structure may be bonded to the foam layer or connected to an edge bond running along the side of the heat exchanger panel.

It may also be provided that the perforated support structure is arranged at a distance from the foam layer. In this case, edge elements may be provided that engage a lateral side of the heat exchanger panel and of the perforated support structure, thereby coupling the perforated support structure to the heat exchanger panel.

In the case of the perforated support structure arranged at a distance from the foam layer, a foil transparent to heat radiation may additionally be provided between the foam layer and the perforated support structure. The foil may in turn rest on the foam layer and be connected thereto, in particular by being bonded to it. By means of the foil, the diffusion tightness toward the boundary surface can be further improved without unduly affecting the heat conduction properties.

The perforated support structure may have a distance of 5 mm, 50 mm, 100 mm, 200 mm, or 300 mm from the foam layer.

The perforated support structure can be retrofitted to the heat exchanger panel or applied to the foam layer. This serves the purpose of being able to visually modify the heat exchanger panel even after installation, making the components more recyclable and easier to separate by type, as well as allowing damage to be repaired more easily and cost-effectively.

The perforated support structure may be designed to be sound-absorbing. For this purpose, the perforated support structure may feature microperforations and/or specific hole sizes. This serves to dampen reverberation times in the room and improve thermal comfort or the perceived comfort in the room.

The edge of each through-hole may have a distance from the edges of the respective adjacent through-holes of at most 3 mm, or at most 2 mm, or at most 1 mm, or at most 0.5 mm, or at most 0.2 mm.

5 The through-holes may have a center-to-center distance of at most 10 mm, at most 8 mm, at most 6 mm, at most 4 mm, or at most 2 mm from one another.

The through-holes may each have a circular shape or a polygonal, preferably hexagonal, shape.

10 A hexagonal shape for the through-holes is preferred, as this allows them to be arranged directly adjacent to each of the neighboring through-holes. The through-holes can be arranged so close together that only a thin web remains between them. As a result, the perforated support structure has a very large opening width.

15 In a top view, the through-holes may each have an area of no more than $1.5 \times 10^3 \text{ mm}^2$ or no more than 750 mm^2 or no more than 100 mm^2 or no more than 10 mm^2 , or no more than 1 mm^2 , or no more than 0.1 mm^2 , or no more than 0.01 mm^2 , or no more than $1 \times 10^3 \text{ } \mu\text{m}^2$, or no more than $100 \text{ } \mu\text{m}^2$.

20 The larger the area of the through-holes in a top view, the greater the aperture width. If large through-holes are selected, particularly those having a hexagonal shape, the aperture width can be maximized.

25 The through-holes may have a depth, extending substantially perpendicular to the boundary surface, of at least 1 cm, or at least 2 cm, or at least 4 cm, or at least 6 cm, or at least 8 cm, or at least 10 cm.

The perforated support structure may, in particular, be a structure in the form of expanded metal.

30 Surface sections of the perforated support structure that extend substantially perpendicular to the boundary surface may exhibit an absorption of at least 50%, at least 60%, at least 70%, at least 80%, or at least 90% with respect to heat radiation, or an absorption of at most 50%, or at most 40%, or at most 30%, or at most 20%, or at most 10%.

35

The surface sections of the perforated support structure extending perpendicular to the boundary surface refer to all those sections that form side walls of the through-holes.

5 The perforated support structure may be a punched or perforated metal foil, a ceramic foil, or a foil made of a carbon fiber composite material, wherein the perforations form the through-holes.

10 The foil may have a thickness of at least 10 μm or at least 100 μm or at least 200 μm or at least 300 μm or at least 400 μm or at least 500 μm and/or a thickness of at most 1000 μm , at most 900 μm , at most 800 μm , at most 700 μm , or at most 600 μm .

15 The perforated support structure may be a metal mesh with mesh openings, wherein the mesh openings form the through-holes.

20 The metal grid may have a thickness of at least 0.01 mm, or at least 0.1 mm, or at least 0.5 mm, or at least 1 mm, and/or a thickness of at most 5 mm, or at most 4 mm, or at most 3 mm, or at most 2 mm.

25 The perforated support structure may be a mesh made of a fiber-reinforced polymer composite material or formed from fibers of a fiber composite material or from fibers of an inorganic material, wherein the mesh openings of the mesh form the through-holes.

30 The grid may have a thickness of at least 10 μm , or at least 100 μm , or at least 500 μm , or at least 1000 μm , or at least 2500 μm , and/or a thickness of at most 10 mm, at most 8 mm, at most 6 mm, or at most 4 mm.

35 The cover layer may be a surface element, in particular a foil, that is at least partially transparent to heat radiation.

The foil may be flexible or formed as a rigid plate-shaped body.

The foil may rest on the foam layer and be firmly connected thereto, in particular by bonding.

40 The foil applied to the foam layer can give it a smooth surface. Such a smooth surface is easier to clean than the typically rough surface of a foam layer. The foil can also serve as a mechanical protective layer to prevent or at least mitigate direct physical impacts on the foam layer. The foil

can additionally ensure that the combination of foam layer and foil is completely airtight, preventing any air from the room from reaching the boundary surface. The foil also allows the heat exchanger panel to be designed to be more visually appealing.

5 It is also possible for the foam layer to have a film-like layer on the front and/or back that is firmly bonded to it. Multiple layers of polymer material and film-like layers may also be provided in any desired layering, whether for decorative purposes using a printing process or for physical reasons to adjust specific radiation or surface properties.

10 The surface element may have a thickness of at least 2 mm, at least 4 mm, or at least 6 mm, and a maximum thickness of 20 mm, 15 mm, or 10 mm.

The surface element may have a transmission of more than about 50%, more than about 70%, or more than about 90% at a wavelength between about 2 μm and about 20 μm or between about 2
15 μm and about 100 μm , at least in a partial region.

The advantages described above with reference to the first aspect of the invention apply analogously to the second aspect of the invention. The various features of the aspects may be combined in any manner, provided they are not technically mutually exclusive.

20 Furthermore, a method according to the invention for manufacturing a heat exchanger panel as described above with reference to the first aspect of the invention is provided. The method comprises the following steps:

- providing a layer of polymer material and a heat exchanger having at least one metal surface,
- 25 - heating a hot-melt adhesive film made of polyurethane,
- pressing the hot hot-melt adhesive film made of polyurethane onto the surface of the layer of polymer material,
- cooling the polyurethane hot-melt adhesive film on the surface of the layer of polymer material,
- applying an adhesive to the cooled polyurethane hot-melt adhesive film on the surface of the
30 layer of polymer material, and
- bonding the layer of polymer material to the at least one metal surface of the heat exchanger using the adhesive.

The method can also be used to manufacture a heat exchanger panel according to the second aspect
35 of the invention, with the exception of the cover layer.

The method of the invention provides a method for bonding or manufacturing a strong bond between a layer of polymer material and a metal surface with thermal conduction properties.

5 The coating process is selected to achieve a durable bond between a typically low-energy polyolefin surface and a metal surface (heat exchanger). Other methods are only feasible for small surfaces, are only implementable at high cost, or do not form a long-term durable bond. For example, a bond created using cyanoacrylate adhesives and primers degrades and dissolves over time due to exposure to moisture. The material composite of the invention creates a permanently
10 strong bond.

The layer of polymer material (foam layer) may be a thin, essentially plate-shaped solid. The polymer material may be an IR-transparent, foamable polymer. The polymer material is preferably a polyolefin, such as polyethylene or polypropylene.

15 It is technically difficult to firmly bond such a foam layer to a smooth metal surface. One reason is that polyethylene and polypropylene are low-energy (nonpolar) materials to which conventional adhesives adhere poorly or not at all at room temperature. Furthermore, such a foam layer typically has a rough and uneven surface, so that it cannot be attached over its entire surface area to a smooth
20 surface. A cost-effective and reliable surface bond is therefore hardly possible using a conventional method.

Other methods, such as thermal pressing, direct hot-melt bonding, or thermal welding, are also hardly feasible due to the typical construction of a heat exchanger with individual tubes that offer
25 only a small surface area on one side.

Therefore, a method is provided by which a permanent bond can be achieved between a layer of low-energy polyethylene or polypropylene and a metal surface.

30 A hot-melt adhesive film made of polyurethane is provided. When heated, the polyurethane of the hot-melt adhesive film exhibits high-energy (highly polar) properties, allowing it to bond very well with the low-energy (non-polar) polyethylene of the foam layer. Thus, the hot-melt adhesive film made of polyurethane provided on the foam layer creates a surface to which another adhesive can be easily applied. By means of this adhesive, the foam layer can be effectively bonded to at least
35 one metal surface of the heat exchanger in a subsequent step.

Since both polymers have matched melting points, the low-energy surface of the polyolefin in the foam layer and the high-energy polyurethane of the hot-melt adhesive film bond with each other at the molecular level within the molten interface.

5

The polyurethane hot-melt adhesive film can be applied like a film to the surface of the foam layer. The polyurethane hot-melt adhesive film may have a thickness of up to 250 μm , or up to 150 μm , or up to 50 μm , or up to 5 μm .

10 Metal particles may be incorporated into the polyurethane hot-melt adhesive film. With such metal particles exhibiting high thermal conductivity, the hot-melt adhesive film can be heated quickly and uniformly, as the metal particles distribute the heat within the adhesive material (inductive heat bonding).

15 Using this method, it is possible to bond the IR-transparent foam layer to the metal heat exchanger surface in large quantities in a cost-effective, highly adhesive, and large-area manner.

The adhesive applied to the cooled polyurethane hot-melt adhesive film is, in particular, a liquid adhesive.

20

The heat exchanger may, as one embodiment, be, for example, a concrete slab, in particular a diffusion-tight concrete slab. The medium line may be a pipe system that is, for example, applied directly to the (raw) concrete slab. The pipe system may be configured as a capillary mat. The transparent layer of polymer material, in particular a foam layer, is applied or adhered to the pipe system. This results in the same principle with the advantage of reduction in installation height, material, and accommodating individual conditions. A disadvantage is on-site fabrication.

25

Optionally, a vapor-impermeable insulation layer, for example in the form of a coating or a water vapor-impermeable insulation layer, can be applied to the concrete ceiling to reinforce the existing structure for the installation. The “panel” is thus formed directly as a surface on the ceiling/wall. The panel can therefore also be firmly connected to the building structure or installed as a superimposed layer directly on a ceiling or wall structure.

30

Alternatively, the heat exchanger can be manufactured directly as a media-carrying pipe with a foam layer. This eliminates the need for a separate heat exchanger, and the product can be

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produced continuously as a pipe. The pipe is then suspended from the ceiling or attached to it, for example, using clamps. A covering may, for example, be formed from a perforated metal sheet, such as expanded metal, which is transparent to heat radiation.

5 Thus, the term “panel” may also refer to bodies with non-planar surfaces, although a panel is generally a roughly planar, plate-shaped component. A non-planar panel may, for example, be a tube or a curved surface. Regardless of its shape, a panel according to the invention comprises a heat exchanger layer and a polymer layer, which is typically foamed.

10 Instead of the polyurethane hot-melt adhesive film, a mass of polyurethane hot-melt adhesive may also be provided, which is heated and, in the heated state, applied to the surface of the layer of polymer material and smoothed out. The mass is then cooled, and an adhesive is applied to the cooled mass. The polyurethane hot-melt adhesive mass exhibits the same properties mentioned above as the polyurethane hot-melt adhesive film.

15 The descriptions of the features of the heat exchanger panel set forth above and the associated advantages apply equally to the heat exchanger panel manufactured by the method described above.

20 Further tasks, features, and advantages of the present invention are apparent from the description and the exemplary embodiment illustrated in the accompanying figures. These show:

Figure 1 a schematic cross-sectional view of a heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a first exemplary embodiment of
25 the invention, in

Figure 2 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to the first exemplary embodiment of the invention, with arrows indicating heat exchange, in

30 Figure 3 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a preferred embodiment of the first exemplary embodiment of the invention, in

- Figure 4 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a further preferred embodiment of the first exemplary embodiment of the invention, in
- 5 Figure 5 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a further embodiment of the first exemplary embodiment of the invention, in
- 10 Figure 6 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a further embodiment of the first exemplary embodiment of the invention, in
- 15 Figure 7 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a further embodiment of the first exemplary embodiment of the invention, in
- 20 Figure 8 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a further embodiment of the first exemplary embodiment of the invention, in
- Figure 9 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a first embodiment of a second exemplary embodiment of the invention, in
- 25 Figure 10 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a further embodiment of the second exemplary embodiment of the invention, in
- 30 Figure 11 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a second embodiment of the second exemplary embodiment of the invention, in
- 35 Figure 12 a schematic cross-sectional view of the heat exchanger panel according to the invention, integrated into a ceiling or wall panel, according to a third exemplary embodiment of the invention, in

Figure 13 an exemplary graph showing the cooling capacity of a cooling surface in a room with and without dew point limitation at 60% relative humidity, and in

5 Figure 14 some (additional) numerical values for the graph shown in Figure 13.

In the following, a heat exchanger panel 1 according to the invention for temperature control of building rooms 2 is described in more detail (Figs. 1 through 9) using a first exemplary embodiment (first aspect of the invention). The building rooms 2 are hereinafter referred to as
10 “room.” The room 2 exhibits either a heat load (cooling scenario) or a cooling load (heating scenario).

The heat exchanger panel 1 comprises a heat exchanger 3. The heat exchanger 3 is integrated into a ceiling or wall panel 4.

15 The heat exchanger 3 comprises at least two parallel straight pipes connected to one another by several thinner pipes that also run parallel. The heat exchanger 3 may also be a tube system with capillary tubes or a capillary tube mat, or may comprise at least one meandering tube. The tubes may be made of metal or plastic and are designed to convey a heat exchanger medium.

20 The heat exchanger medium may be a refrigerant (cooling scenario) or a heating medium (heating scenario) in the form of a fluid that serves to absorb or release heat. The cooling or heating medium may, for example, be cooled or heated water.

25 The heat exchanger 3 may be made of the same material as the ceiling or wall panel 4. The heat exchanger 3 may also be directly flowed through with a refrigerant, e.g., R32 or R290, but preferably water or a water-glycol mixture.

A heat pump (not shown) is provided to supply cooled or heated water to the heat exchanger 3 via
30 a pipe (not shown). The water is fed directly from the pipe into the at least one tube of the heat exchanger 3. The heat pump and the heat exchanger 3 form a circuit.

For example, a single heat pump may be provided in a building, which is connected via multiple pipes to a large number of heat exchanger panels 1 on different floors and supplies the cooled or
35 heated water to the heat exchangers 3 of the heat exchanger panels 1. Alternatively, any cooling

or heating sink can be integrated into the circuit. This also allows for systems with solar cooling, geothermal probes, or groundwater cooling, and consequently renewable cooling sources.

5 The pipes of the heat exchanger 3 are installed in the ceiling or wall panel 4 in such a way that a material of the ceiling or wall panel 4 fills the interstices between the pipes of the heat exchanger 3. The material is preferably a diffusion-tight thermal insulation material.

The heat exchanger 3 has a boundary surface 5. The boundary surface 5 is the surface of the heat exchanger 3 that faces the room 2.

10 The heat exchange between the room 2 and the heat exchanger medium flowing through the tubes of the heat exchanger 3 essentially takes place at the boundary surface 5.

15 Heat radiation 8 is generally emitted from the boundary surface 5 both into the room 2 and into the interior of the heat exchanger 3. However, heat radiation 8 can only propagate inside the heat exchanger 3 if the heat exchanger 3 is made of a low-density material. The higher the density, the lower the propagation of heat via heat radiation 8 and the stronger the transfer via thermal conduction 9.

20 On the side of the boundary surface 5 facing room 2, a layer 6 of polymer material is arranged over the entire surface. The layer 6 of polymer material is hereinafter referred to as the “foam layer.”

25 The foam layer 6 is bonded to the boundary surface 5. The adhesive is designed to provide thermal conduction and is at least partially permeable to heat radiation 8.

On one side, the foam layer 6 is connected to the heat exchanger 3 at the boundary surface 5, and on the other side, it has a free surface 7 facing the room 2, which is hereinafter referred to as the “surface of the foam layer” or simply as the “surface.”

30 The foam layer 6 is made of a polyolefin, such as polyethylene or polypropylene, and contains gas bubbles or gas chambers, so that it is at least partially permeable to heat radiation 8.

35 With respect to heat radiation 8, the foam layer 6 exhibits a transparency of no more than 30% in a wavelength range between 9 μm and 11 μm .

The foam layer 6 has a thickness in the range of 2 mm to 25 mm.

5 The density of gas bubbles or gas chambers in the foam layer 6 and the thickness of the foam layer 6 are selected such that a transparency of the foam layer 6 at a wavelength between 9 μm and 11 μm of no more than 30% is achieved.

A foam layer 6 made of a polyolefin with such transparency has a relatively high material density.

10 Considering the cooling scenario, despite the relatively low transparency, sufficient heat from room 2 passes through the foam layer 6 to the boundary surface 5 to achieve efficient cooling of room 2. The heat reaches the boundary surface 5 through a combination of the foam layer's 6 permeability to heat radiation 8 and thermal conduction 9 in the region of the boundary surface 5.

15 At the same time, the foam layer 6, with a transparency of no more than 30% in a wavelength range between 9 μm and 11 μm , absorbs sufficient heat from room 2 so that no heat flow occurs from the boundary surface 5 to the surface 7 that reaches the surface 7 and cools it below the average room temperature of room 2. This would lead to the formation of condensate on the surface 7 due to the room air.

20 The heat is transferred, on the one hand, by convection 10 (convective heat exchange) from the room air at surface 7 to said surface and then, by means of thermal conduction 9, into the material of the foam layer 6 in a region of the surface 7. On the other hand, due to the foam layer's 6 increased absorptive capacity (resulting from its low transparency), heat is input into the volume
25 of the foam layer 6 via heat radiation 8.

In the heating scenario, when the foam layer 6 has a transparency of no more than 30% in a wavelength range between 9 μm and 11 μm , heat is emitted from the boundary surface 5 into the room 2, whereby, at the same time, no heat flow from the boundary surface 5 reaches the surface
30 7, causing the foam layer 6 at the surface 7 to remain cool enough so that the loss of convective heat at the surface 7 is kept low.

In a preferred embodiment (Fig. 3), an additional thermally conductive layer 11 is applied between the heat exchanger 3 and the foam layer 6. The thermally conductive layer 11 thermally connects

the surfaces of the tubes of the heat exchanger 3. This creates a large total surface area with uniform temperature distribution.

In a further preferred embodiment (Fig. 4), the material of the heat exchanger 3 and/or of the ceiling or wall panel 4 is mixed with highly radiation-absorbing particles 12, such as carbon particles. The particles 12 absorb heat radiation 8 emanating from the room 2 as well as the heat radiation 8 emitted by the heat exchanger 2 itself. The particles 11 absorb all heat radiation 8 very quickly, preventing it from penetrating deeply into the material. The absorbed heat radiation 8 is converted into heat and contributes to the heating of the heat exchanger 3 via thermal conduction 9.

Any particles with good absorptive capacity can be used as radiation-absorbing particles 12. These can also be metal particles, for example. If the heat exchanger 3 and/or the ceiling or wall panel 4 as well as the foam layer 6 consist of a polymer material, carbon particles or particles of a radiation-absorbing carbon compound are suitable for this purpose. From a chemical perspective, polymer materials are also carbon compounds, which keeps the variety of materials limited and maintains high recyclability.

According to a further embodiment (Fig. 5), a sound-absorbing layer 13 is incorporated into the material of the ceiling or wall panel 4. The sound-absorbing layer 13 is preferably an acoustic foam and is preferably formed from the same material as the diffusion-tight thermal insulation material of the ceiling or wall panel 4. The acoustic foam has a more open-celled surface compared to the thermal insulation material. The sound-absorbing layer 13 reduces the sound level and the reverberation time in room 2.

According to a further embodiment (Fig. 6), a moisture-wicking layer 14 is provided between the boundary surface 5 and the foam layer 6. The moisture-wicking layer 14 is significantly thinner than the foam layer 6 and lies both directly on the boundary surface 5 and against the foam layer 6. The moisture-wicking layer 14 is, for example, a capillary-active nonwoven fabric through which any moisture that may accumulate - which cannot be entirely ruled out - can be wicked away. It extends into an edge region of the heat exchanger panel 1 in such a way that it protrudes at the boundary surface 5, allowing the wicked-away moisture to dry in the room air.

According to a further embodiment (Fig. 7), a selective coating 15 is provided on the surface 7 of the foam layer 6. The selective coating 15 is a polymer membrane made of polyethylene or

polypropylene that is transparent to heat radiation 13. It is preferably provided for decorative reasons, but can also serve technical purposes.

In another embodiment (Fig. 8), lighting elements 16 are provided between the boundary surface 5 and the foam layer 6. The lighting elements 16 may, for example, be LEDs that are mounted at a distance from one another on the boundary surface 5. Thus, a ceiling or wall panel 4 can not only serve to regulate the temperature of the room 2, but also contribute to the visual and technical design of the room 2 through the lighting elements 16.

The following describes a method for temperature control of a building room (room) 2 using a heat exchanger panel 1 according to the invention.

In the cooling scenario, a boundary surface 5 of the heat exchanger panel 1 facing the room 2 is brought to a temperature lower than the heat load or the room temperature. For this purpose, a refrigerant is used as the heat exchanger medium, which flows through at least one tube of a heat exchanger 3 of the heat exchanger panel 1.

The refrigerant, for example in the form of chilled water, is supplied to the heat exchanger 3 by means of a heat pump (not shown) and fed to the tube of the heat exchanger 3 via a pipe (not shown).

A layer 6 of polymer material (foam layer) is arranged on the boundary surface 5.

The foam layer 6 ensures, on the one hand, that no room air can reach the cool boundary surface 5 directly, thereby preventing condensation of moisture from the room air of room 2 at the boundary surface 5.

On the other hand, the foam layer 6 ensures that no heat flow occurs from the cool boundary surface 5 to a warm surface 7 of the foam layer 6. Thus, no condensate can form on the surface 7 of the foam layer 6 either.

In this way, the boundary surface 5 can be brought to a temperature below the dew point, while the surface 7 of the foam layer 6 facing room 2 nevertheless remains at a surface temperature above the dew point (average room temperature).

Heat can thus be extracted from the heat load in room 2 via the boundary surface 5. The heat extraction occurs via heat radiation 8, which can at least partially pass through the foam layer 6 to the boundary surface 5 and is absorbed by the foam layer 6 in a region of the boundary surface 5, and then reaches the boundary surface 5 via thermal conduction 9.

5 At the same time, the foam layer 6 absorbs sufficient heat from room 2 (via thermal conduction 9 from convective heat 10 in a region of surface 7 and via heat radiation 8 throughout the entire volume of the foam layer 6), so that this heat exceeds the heat flow from the boundary surface 5 to the surface 7, preventing it from reaching the surface 7 to cool it down.

10 In the heating scenario, however, the boundary surface 5 of the heat exchanger panel 1 facing room 2 is brought to a temperature higher than that as compared to a cooling load. A heating medium is used as the heat exchanger medium.

15 The heating medium, for example in the form of heated water, is supplied to the heat exchanger 3 by means of the heat pump and fed to the pipe of the heat exchanger 3 via the piping.

The foam layer 6 ensures that no heat flow occurs from the warm boundary surface 5 to the cool surface 7 of the foam layer 6. This prevents the loss of convective heat at the surface 7.

20 Heat can thus be supplied to the cooling load via the boundary surface 5. Since the foam layer 6 is at least partially transparent to heat radiation 13, the room 2 is heated by heat radiation 13.

A second exemplary embodiment (second aspect of the invention) is described below (Figs. 9 through 11). Identical parts are designated by the same reference numerals as in the previous exemplary embodiment. Furthermore, the above explanations apply equally to the corresponding parts of the second exemplary embodiment. The second exemplary embodiment differs from the first exemplary embodiment in that a cover layer 17 is arranged on the surface 7 of the layer 6 made of a polymer material. The cover layer 17 is designed to be at least partially permeable to
30 heat radiation 8.

In a first embodiment of the second exemplary embodiment (Fig. 9), the cover layer 17 is a perforated support structure 18.

35 The perforated support structure 18 is adhered to the foam layer 6.

The perforated support structure 18 has a plurality of through-holes 19 that are arranged substantially perpendicular to the surface 7 of the foam layer 6. The through-holes 19 thus extend from a surface of the perforated support structure 18 facing the room 2 to the foam layer 6.

5

The through-holes 19 have a depth of 1 cm to 10 cm perpendicular to the boundary surface.

The perforated support structure 18 provides the heat exchanger panel 1 with increased stability. At the same time, the perforated support structure 18 is intended to give a side of the heat exchanger panel 1 facing the room 2 a visually appealing appearance.

10

The spacing between the through-holes 19 and the area of the through-holes 19 in a top view are selected such that the perforated support structure 18 has the largest possible opening width. Thus, the perforated support structure 18 is nearly transparent to heat radiation 8.

15

The perforated support structure 18 is made of metal, so that it is a good conductor of heat. Thus, it conducts a heat flow from the room 2 to the surface 7.

The through-holes 19 each have surface sections 20 extending perpendicular to the boundary surface 5. These surface sections 20 form the walls of the through-holes 19.

20

The surface sections 20 are preferably designed or coated in such a way that they exhibit a high reflectivity for heat radiation 8. In this way, the heat radiation 8 is reflected through them with as little loss as possible.

25

Due to the through-holes 19 and their large opening width, air from the room 2 can reach the foam layer 6 almost unimpeded. The perforated support structure 18 thus provides the heat exchanger panel 1 with additional stability without significantly impairing the properties of the heat exchanger panel 1 described in the first exemplary embodiment.

30

In a further embodiment (Fig. 10), the perforated support structure 18 may also be arranged at a distance from the foam layer 6. In this case, at least one edge element 24 may be provided, which engages the heat exchanger panel 1 and the perforated support structure 18 at the sides thereof, thereby coupling the perforated support structure 18 to the heat exchanger panel 1.

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According to a second embodiment of the second exemplary embodiment (Fig. 11), the cover layer 17 is a surface element in the form of a foil 21.

5 The foil 21 is adhered to the foam layer 6. The adhesive is designed for good thermal conduction and is at least partially permeable to heat radiation.

The foil 21 is made of a polymer material, in particular the same material as the foam layer 6. The foil 21 is thus designed to be at least partially transparent to heat radiation 8.

10 The foil 21 has a thickness between 2 mm and 20 mm. At a wavelength between approximately 2 μm and approximately 20 μm or between approximately 2 μm and approximately 100 μm , the foil 21 exhibits a transmission of more than approximately 50%, or more than approximately 70%, or more than approximately 90%, at least in a partial region.

15 The thickness and transmittance of foil 21 are selected such that sufficient heat radiation 8 can pass through and enough heat reaches the foam layer 6 via thermal conduction 9 for the foam layer 6 to retain the properties mentioned in the first exemplary embodiment.

20 The foil 21 on the foam layer 6 gives it a smooth surface. Such a smooth surface is easier to clean than the typically rough surface of such a foam layer 6.

The foil 21 also serves as a mechanical protective layer to prevent or at least mitigate direct physical impacts on the foam layer 6.

25 Foil 21 also ensures that the combination of foam layer 6 and foil 21 is completely airtight, preventing any air from passing from room 2 to boundary surface 5.

30 The elements mentioned in the first exemplary embodiment with reference to the further embodiments (thermally conductive layer 11, radiation-absorbing particles 12, sound-absorbing layer 13, moisture-wicking layer 14, selective coating 15, and lighting element 16) may also be provided for the second exemplary embodiment.

A method for manufacturing a heat exchanger panel 1 as described above with reference to the first exemplary embodiment is provided below.

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The method can also be used to manufacture a heat exchanger panel 1 according to the second exemplary embodiment, with the exception of the cover layer 17.

5 A layer 6 made of polymer material (foam layer) and a heat exchanger 3 with a metal tube are provided.

The metal tube of the heat exchanger 3 is arranged such that, on one side of the heat exchanger 3, there are several parallel surfaces of the metal tube. The foam layer 6 is to be firmly bonded to these surfaces of the metal tube.

10 The foam layer 6 is a thin, essentially plate-shaped solid made of an IR-transparent, foamable polymer material. The polymer material is a polyolefin, such as polyethylene or polypropylene.

15 A hot-melt adhesive film made of polyurethane is heated. The heated hot-melt adhesive film is hot-pressed onto a surface of the foam layer 6 while still in a heated state.

After the polyurethane hot-melt adhesive film has cooled on the surface of the foam layer 6, an adhesive, in particular a liquid adhesive, is applied to the cooled mass.

20 The foam layer 6 is pressed onto the surfaces of the heat exchanger 3 and bonded to the surfaces by means of the adhesive.

This method achieves a permanent bond between a layer of low-energy polyethylene or polypropylene and a metal surface.

25 When heated, the polyurethane hot-melt adhesive film exhibits high-energy (highly polar) properties, which allow it to bond very effectively with the low-energy (nonpolar) polyethylene of foam layer 6. The bonding occurs as both polymers melt, linking together at the molecular level to form a strong composite. The melting points are adjusted such that they are close to each other.

30 The hot-melt adhesive film allows a surface to be created on the foam layer 6 to which another adhesive can be easily applied. Said another adhesive allows the foam layer 6 to be effectively bonded to the metal surfaces of the heat exchanger 3 in a subsequent step.

A third exemplary embodiment is described below (Fig. 12). Identical parts have the same reference symbols as in the previous embodiments. Furthermore, the above explanations apply equally to the corresponding parts of the third exemplary embodiment.

- 5 The heat exchanger panel 1 is provided, comprising the heat exchanger 3. The heat exchanger 3 has the boundary surface 5.

A surface element 23 is provided between the boundary surface 5 and the room 2, such that an interstice 22 is enclosed between the boundary surface 5 and the surface element 23. The surface
10 element 23 is arranged substantially parallel to the boundary surface 5.

The interstice 22 is bounded laterally by a fully circumferential edge element 24. The edge element 24 is firmly connected to the heat exchanger panel 1 and extends beyond the boundary surface 5 into the room 2.

15 The surface element 23 is a foil and is designed to be at least partially permeable to heat radiation 8. The foil is flexible and bonded to and tensioned at one edge of the edge element 24 in a diffusion-tight manner. The surface element 23 may also be a rigid plate-shaped body connected to the edge of the edge element 24. The surface element 23 may be bonded to the edge element 24.

20 The surface element 23 is made of a polymer material.

The surface element 23 has a thickness of at least 2 mm, at least 4 mm, or at least 6 mm, and a maximum thickness of 20 mm, 15 mm, or 10 mm.

25 At wavelengths between approximately 2 μm and approximately 20 μm , or between approximately 2 μm and approximately 100 μm , the surface element 23 exhibits a transmittance of more than approximately 50%, or more than approximately 70%, or more than approximately 90%, at least in a partial region.

30 The interstice 22 is filled with air. This allows the surface element 23 to be designed so as to be particularly thin. If there were a vacuum in the interstice 22, a surface element 23 that is too thin would be sucked into the interstice 22. An inert gas may also be provided in the interstice 22.

35 The interstice 22 can also be virtually airless if the surface element 23 is of sufficient thickness.

Due to the interstice 22 and the surface element 23, no ambient air can reach the boundary surface 5 and condense there. The heat exchange between the boundary surface 5 and the room 2 occurs almost exclusively via heat radiation 8.

5 A perforated support structure 14 is arranged on a side 25 of the surface element 23 facing room 2.

10 The perforated support structure 14 is firmly connected laterally to the edge element 24. The perforated support structure 14 may be adhesively bonded to the edge element 24.

The perforated support structure 14 may be arranged in contact with the surface element 23 or slightly spaced from the surface element 23.

15 It may also be provided that the surface element 23 is not connected to the edge element 24, but is connected, in particular adhered, only to the perforated support structure 14. Diffusion tightness toward the edge element 24 is important in this context.

20 The perforated support structure 14 also imparts increased stability to the heat exchanger panel 1 according to the third exemplary embodiment. Since the perforated support structure 14 ensures the stability of the heat exchanger panel 1 and protects the surface element 23 toward the room 2, the surface element 23 can be designed so as to be particularly thin. This makes it particularly transparent to heat radiation 8, making the heat exchange of the heat exchanger panel 1 very effective.

25

List of Reference Symbols

	1	heat exchanger panel
	2	building room
5	3	heat exchanger
	4	ceiling or wall panel
	5	boundary surface
	6	layer of polymer material
	7	surface of the layer
10	8	heat radiation
	9	thermal conduction
	10	convective heat exchange
	11	thermally conductive layer
	12	radiation-absorbing particles
15	13	sound-absorbing layer
	14	moisture-wicking layer
	15	selective coating
	16	lighting element
	17	cover layer (perforated support structure/foil)
20	18	perforated support structure
	19	through-hole
	20	surface section
	21	foil
	22	interstice
25	23	surface element
	24	edge element
	25	room-facing side

Claims

1. A heat exchanger panel for temperature control of building rooms, comprising
 - a heat exchanger comprising a medium line for conducting a heat exchanger medium, and a
 - 5 heat exchanger wall in thermal contact with the medium line, wherein the heat exchanger wall has a boundary surface facing the building room to be temperature-controlled, which can be brought to a lower temperature relative to a heat load or to a higher temperature relative to a cooling load, and
 - a layer of polymer material arranged on the boundary surface of the heat exchanger, wherein
 - 10 the layer comprises a plurality of gas bubbles or a plurality of gas chambers such that it is at least partially permeable to heat radiation,
 - characterized in that
 - the layer of polymer material has a transparency of no more than 30% in a wavelength range of the heat radiation between 9 μm and 11 μm .
 - 15
2. The heat exchanger panel according to claim 1,
characterized in that
the layer of polymer material has a transparency of no more than 25%, or no more than 20%,
or no more than 15%, or no more than 10%, or no more than 5%, in the wavelength range of
20 the heat radiation between 9 μm and 11 μm .
3. The heat exchanger panel according to claim 1 or 2,
characterized in that
the layer of polymer material has a transparency of no more than 30%, or no more than 25%,
25 or no more than 20%, or no more than 15%, or no more than 10%, or no more than 5%, in a wavelength range of heat radiation between approximately 2 μm and approximately 20 μm ,
or between approximately 2 μm and approximately 100 μm .
4. The heat exchanger panel according to any one of claims 1 to 3,
30 characterized in that
the layer of polymer material has a thickness of at least 2 mm, at least 3 mm, at least 4 mm,
at least 5 mm, at least 6 mm, at least 7 mm, and at least 8 mm, and/or a thickness of at most
28 mm, at most 27 mm, at most 26 mm, at most 25 mm, at most 24 mm, at most 23 mm, or at
35 most 22 mm.

5. The heat exchanger panel according to any one of claims 1 to 4,
characterized in that
the layer of polymer material is formed from a polyolefin, preferably polyethylene or
polypropylene, or a mixture thereof.

- 5
6. The heat exchanger panel according to any one of claims 1 to 5,
characterized in that
the layer of polymer material is a layer of foam, in particular closed-cell foam, or a bubble
film or hollow-chamber film, and/or the layer completely covers the boundary surface.

- 10
7. The heat exchanger panel according to any one of claims 1 to 6,
characterized in that
the heat exchanger comprises at least one straight or meandering tube and/or is a plate heat
exchanger.

- 15
8. The heat exchanger panel according to any one of claims 1 to 7,
characterized in that
a heat-insulating and/or sound-absorbing layer and/or a layer impermeable to water vapor
diffusion is provided on a side of the heat exchanger facing away from the building room to
be temperature-controlled.
- 20

9. A heat exchanger panel for temperature control of building rooms, in particular according to
any one of claims 1 to 8, comprising
- a heat exchanger comprising a medium line for conducting a heat exchanger medium, and a
- 25
- heat exchanger wall which is in thermal contact with the medium line, wherein the heat
exchanger wall has a boundary surface facing the building room to be temperature-controlled,
which can be brought to a lower temperature relative to a heat load or to a higher temperature
relative to a cooling load,
 - a layer of polymer material arranged on the boundary surface of the heat exchanger, wherein
- 30
- the layer comprises gas bubbles or gas chambers such that it is at least partially transparent to
heat radiation, and
 - a cover layer arranged on the layer of polymer material and at least partially transparent to
heat radiation,
- 35
- wherein the cover layer comprises a plurality of through-holes.

10. The heat exchanger panel according to claim 9,
characterized in that
the cover layer is a perforated support structure comprising a plurality of through-holes, such
that it is substantially transparent to heat radiation.

5

11. The heat exchanger panel according to claim 10,
characterized in that
an edge of each through-hole is spaced from the edges of the respective adjacent through-
holes by a maximum of 3 mm, 2 mm, 1 mm, 0.5 mm, or 0.2 mm.

10

12. The heat exchanger panel according to claim 10 or 11,
characterized in that
the through-holes have a center-to-center distance of at most 10 mm, at most 8 mm, at most 6
mm, at most 4 mm, or at most 2 mm.

15

13. The heat exchanger panel according to any one of claims 10 to 12,
characterized in that
the through-holes each have a round shape or a polygonal, preferably a hexagonal, shape.

20

14. The heat exchanger panel according to any one of claims 10 to 13,
characterized in that,
in a top view, the through-holes each have an area of no more than $1.5 \times 10^3 \text{ mm}^2$, or no more
than 750 mm^2 , or no more than 100 mm^2 , or no more than 10 mm^2 , or no more than 1 mm^2 , or
no more than 0.1 mm^2 , or no more than 0.01 mm^2 , or no more than $1 \times 10^3 \text{ } \mu\text{m}^2$, or no more
than $100 \text{ } \mu\text{m}^2$.

25

15. The heat exchanger panel according to any one of claims 10 to 14,
characterized in that
the through-holes have a depth extending substantially perpendicular to the boundary surface
of at least 1 cm, or at least 2 cm, or at least 4 cm, or at least 6 cm, or at least 8 cm, or at least
10 cm.

30

16. The heat exchanger panel according to any one of claims 10 to 15,
characterized in that

surface sections of the perforated support structure which extend substantially perpendicular to the boundary surface exhibit an absorption with respect to heat radiation of at least 50%, or at least 60%, or at least 70%, or at least 80%, or at least 90%, or an absorption of at most 50%, or at most 40%, or at most 30%, or at most 20%, or at most 10%.

5

17. The heat exchanger panel according to any one of claims 10 to 16,
characterized in that
the perforated support structure is a punched or perforated metal foil, a ceramic foil, or a foil
made of a carbon fiber composite material, wherein the holes or perforations form the through-
10 holes.

18. The heat exchanger panel according to any one of claims 10 to 16,
characterized in that
the perforated support structure is a metal mesh with mesh openings, wherein the mesh
15 openings form the through-holes.

19. The heat exchanger panel according to any one of claims 10 to 16,
characterized in that
the perforated support structure is a mesh made of a fiber-reinforced polymer composite
20 material or is formed from fibers of a fiber composite material or from fibers of an inorganic
material, wherein mesh openings of the mesh form the through-holes.

20. The heat exchanger panel according to claim 9,
characterized in that
25 the cover layer is a surface element, in particular a foil, which is at least partially transparent
to heat radiation.

21. The heat exchanger panel according to claim 20,
characterized in that
30 the surface element has a thickness of at least 2 mm, or at least 4 mm, or at least 6 mm, and a
maximum thickness of 20 mm, or 15 mm, or 10 mm.

22. The heat exchanger panel according to claim 20 or 21,
characterized in that

the surface element has a transmission of more than about 50%, or more than about 70%, or more than about 90%, at least in a partial region, at a wavelength between about 2 μm and about 20 μm , or between about 2 μm and about 100 μm .

- 5 23. A method for manufacturing a heat exchanger panel according to any one of claims 1 to 8, comprising
- providing a layer of polymer material and a heat exchanger having at least one metal surface,
 - heating a hot-melt adhesive film made of polyurethane,
 - pressing the hot hot-melt adhesive film made of polyurethane onto a surface of the layer of
10 polymer material,
 - cooling the polyurethane hot-melt adhesive film on the surface of the layer of polymer material,
 - applying an adhesive to the cooled polyurethane hot-melt adhesive film on the surface of the layer of polymer material, and
15 - bonding the layer of polymer material to the at least one metal surface of the heat exchanger using the adhesive.