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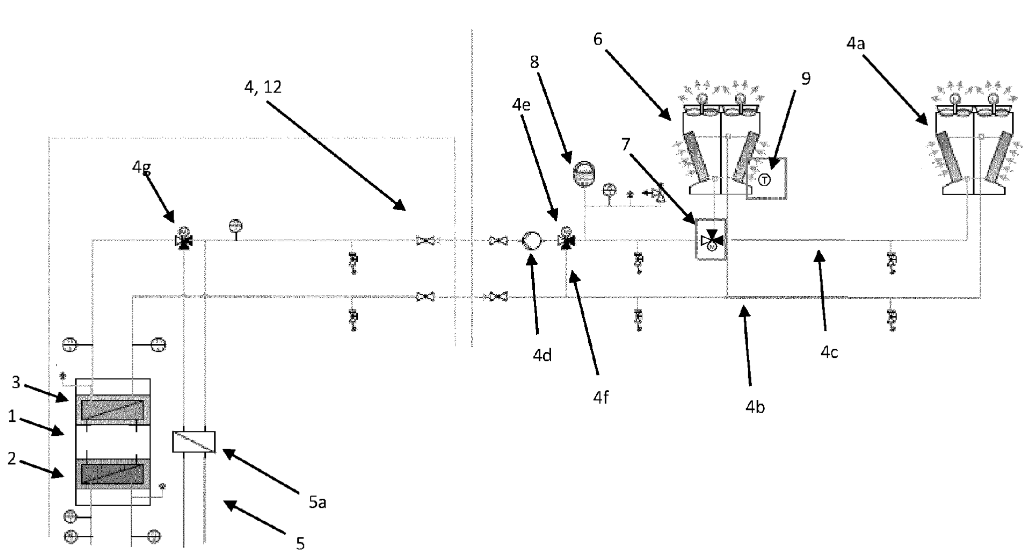
(54) A RE-COOLING DEVICE FOR A REFRIGERATION SYSTEM, A REFRIGERATION SYSTEM EQUIPPED THEREWITH AND A METHOD FOR CONTROLLING A RE-COOLING DEVICE

(57) A re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, comprising a cooling water circuit (12) connected or to be connected to a heat exchanger (3) of a compression refrigeration machine (chiller) (1) and/or a free-cooling heat exchanger (5a), a first re-cooling module (4a), which is connected to the cooling water circuit (12) and is preferably arranged or to be arranged outside a building envelope in order to be able to dissipate heat to the environment, a second re-cooling module (6), which is preferably arranged or to be arranged inside a building envelope in order to be able to dissipate heat to the interior of the building, the second re-cooling module (6) being connected to the cooling water circuit (12) via a changeover valve (7) in such a way that a cooling medium can flow through it selectively, and a control system which is designed to open and close the changeover valve (7) of the second re-cooling module (6) as a function of a predetermined outside temperature and/or a predetermined time of year to provide heating support for the interior of the building and raise an efficiency ratio.

Fig. 1



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Description

[0001] The present invention relates to a re-cooling device for a refrigeration system for an industrial process or an industrial machine, a refrigeration system equipped therewith and a method for controlling a re-cooling device of a refrigeration system for an industrial process or an industrial machine.

[0002] Waste heat from industrial processes or industrial machines such as machine tools, for example those that use a laser, and which are cooled by means of an external refrigeration system in order to maintain defined operating conditions (more precisely: certain low working or process temperatures), is nowadays often dissipated using a compression refrigeration machine (chiller). For this purpose, an evaporator of the chiller is connected to a cold water circuit via a heat exchanger for material decoupling, which supplies the waste heat from a cooling circuit of the industrial process or industrial machine as hot water (heated cold water) and returns cold water at a lower temperature, tot he cooling circuit. Furthermore, a condenser of the chiller - in the case of liquid cooling as opposed to direct cooling - is connected to a separate cooling water circuit via a further heat exchanger for material decoupling, which removes the heat generated during condensation to a re-cooling device via the the cooling water and returns the cooling water cooled by means of a re-cooling module with a fan or blower. The heat in the re-cooling module is forcibly dissipated to the outside air/outside environment by the fan or blower.

[0003] The terms chiller, refrigeration machine, cooling unit are used synonymously in the following for a self contained mechanical refrigeration generator or compressor refrigeration generator whose refrigerant-carrying components such as evaporator, compressor, condenser and expansion device are pre-assembled at the factory and form a closed refrigerant or cooling circuit - in contrast to a direct evaporator. The working medium of the chiller can be any refrigerant known in the state of the art, but preferably water-based refrigerants for environmental and regulatory reasons.

[0004] In a so-called free-cooling operation, a free-cooling device is optionally provided, which bypasses the chiller completely or partially at suitably low outside temperatures, in that a heat exchanger thermally connects the cold water circuit directly to the re-cooling device, so that the operation of the chiller can be throttled or stopped completely in order to realize significant energy savings (in particular by switching off or throttling the refrigerant compressor of the chiller and any peripheral devices that are not required), if ambient temperatures allow sufficient or supportive removal of the waste heat from the industrial process or industrial machine via the re-cooling device without mechanical refrigeration by the chiller. These operating modes with free cooling are also referred to as "winter operation" or "transitional operation", while in "summer operation" the chiller provides the necessary cooling energy by supplying considerable external electrical energy.

[0005] At the same time, the buildings of industrial plants, at least in areas where no or hardly any process heat is generated, i.e. warehouses and administrative areas, for example, are additionally heated within the building envelope, at least in the winter or during the transitional periods. External energy in the form of electricity and/or primary energy sources such as gas or oil is used for this, which reduces the overall efficiency of an industrial plant.

[0006] The object of the invention is to provide a re-cooling device for a refrigeration system for an industrial process or an industrial machine, a refrigeration system equipped therewith and a method for controlling a re-cooling device of a refrigeration system for an industrial process or an industrial machine, with which a seasonal building heating support can be realized by process heat that was previously dissipated and wasted, and with which an improvement in the overall efficiency of an industrial plant can be achieved.

[0007] For the solution, the invention proposes a re-cooling device for a refrigeration system for an industrial process or an industrial machine with the features of claim 1 or 6, a refrigeration system equipped therewith with the features of claim 9 and a method for controlling a re-cooling device of a refrigeration system for an industrial process or an industrial machine with the features of claim 10 or 14. Preferred embodiments are defined in the respective dependent claims.

[0008] Specifically, the invention thus proposes a re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, comprising

- a cooling water circuit connected or to be connected to a heat exchanger of a compression refrigeration machine (chiller) and/or a free-cooling heat exchanger,

- a first re-cooling module, which is connected to the cooling water circuit and is preferably arranged or to be arranged outside a building envelope in order to be able to dissipate heat to the environment,

- a second re-cooling module, which is preferably arranged or to be arranged inside a building envelope in order to be able to dissipate heat to the interior of the building, the second re-cooling module being connected to the cooling water circuit via a changeover valve in such a way that a cooling medium can flow through it selectively, and

- a control system which is designed to open and close the changeover valve of the second re-cooling module as a function of a predetermined outside temperature and/or a predetermined time of year.

[0009] Specifically, the invention also proposes an alternative re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, with

a cooling water circuit connected or to be connected to a heat exchanger of a compression refrigeration machine (chiller) and/or a free-cooling heat exchanger,

a first re-cooling module, which is connected to the cooling water circuit and is preferably arranged or to be arranged outside a building envelope in order to dissipate heat to the environment,

a second re-cooling module, which is preferably arranged or to be arranged inside a building envelope in order to dissipate heat to the interior of the building, the second re-cooling module being connected via a changeover valve to a return of a cold water circuit, which is connected or to be connected to a heat exchanger of the compression refrigeration machine (chiller), in such a way that a cooling medium can flow through it selectively, and

a control system which is designed to open and close the changeover valve of the second re-cooling module as a function of a predetermined outside temperature and/or a predetermined time of year.

[0010] Further, the invention also proposes a method for controlling a re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, which has

a cooling water circuit connected to a heat exchanger of a compression refrigeration machine (chiller) and/or a free-cooling heat exchanger,

a first re-cooling module which is connected to the cooling water circuit and is preferably arranged outside a building envelope in order to be able to dissipate heat to the environment, and

a second re-cooling module, which is preferably arranged inside a building envelope in order to be able to dissipate heat to the interior of the building, the second re-cooling module being connected to the cooling water circuit via a changeover valve in such a way that a cooling medium can flow through it selectively,

wherein the changeover valve of the second re-cooling module is opened and closed as a function of a predetermined outside temperature and/or a predetermined season in order to dissipate heat to the interior of the building.

[0011] Finally, the invention also proposes an alternative method for controlling a re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, which has

a cooling water circuit connected to a heat exchanger of a compression refrigeration machine (chiller) and/or a free-cooling heat exchanger,

a first re-cooling module which is connected to the cooling water circuit and is preferably arranged outside a building envelope in order to be able to dissipate heat to the environment, and

a second re-cooling module, which is preferably arranged inside a building envelope in order to be able to dissipate heat to the interior of the building, the second re-cooling module being connected via a changeover valve to a return flow of a cold water circuit, which is connected to a heat exchanger of the compression refrigerating machine (chiller), in such a way that a cooling medium can flow through it selectively,

wherein the changeover valve of the second re-cooling module is opened and closed depending on a predetermined outside temperature and/or a predetermined time of year in order to release heat to the interior of the building.

[0012] By selectively activating the second re-cooling module, which is arranged or to be arranged inside a building envelope, at least a part of the process heat previously dissipated to the environment and lost via the re-cooling device and thus wasted can be recovered in a suitable temperature scenario, typically in winter and possibly also in transitional periods. and thus used as a seasonal building heating support, whereby heating energy for the building previously supplied externally can be saved and consequently an improvement in the overall efficiency can be achieved, while the required re-cooling of the refrigeration system is still possible.

[0013] In the alternative, in which the second re-cooling module is arranged on the cold water side in the return of the cooling circuit from the industrial process or the industrial machine, the waste heat from the return can always be introduced into the interior of the building. However, the integration of the second re-cooling module in the return on the cold water side can lead to a higher pressure loss in the cold water circuit, which may have to be compensated for by a higher delivery rate of the circulation pump, so that the resulting higher energy requirement of the pump must be weighed against the heating energy gained with regard to the overall efficiency. In addition, controlling the cold water temperature to a setpoint in the cold water circuit can be somewhat more difficult to realize due to the additional heat sink in the form of the second re-cooling module.

[0014] Preferably, the first re-cooling module and the second re-cooling module are connected in parallel with respect to the cooling water circuit. This arrangement enables a comparatively simple implementation, for which only a second re-cooling module, a temperature sensor and a changeover valve, for example a 3-way valve, are required.

[0015] Preferably, the first re-cooling module and the second re-cooling module are connected in series with respect to the cooling water circuit. In addition to the above-mentioned effect, this solution makes it possible to provide a higher heat exchanger surface area (double in the case of two identical re-cooling modules) with a lower gradient to the outside temperature due to the fact that the re-cooling module downstream in the series connection only has to deliver a lower output. As a result, the duration of the free-cooling operation can be extended when operating two re-cooling modules and corresponding energy savings can be realized with a positive effect on the efficiency of the cooling system.

[0016] Furthermore, if the re-cooling modules each have one (or more) fan(s) or ventilator(s) or blower(s), each of which is/are controllable as to their rotational speed, it is possible to reduce the fan speed in this arrangement, which leads to a further reduction in power consumption, since - with the same volume flow - 4 fans in 2 modules at reduced rotational speed, for example, have a lower power consumption than 2 fans of a single module at full rotational speed.

[0017] Preferably, the second re-cooling module is arranged upstream of the first re-cooling module in the cooling water circuit. This allows a greater amount of waste heat from the cooling water circuit of the re-cooling device to be introduced into the interior of the building and only a smaller proportion of the waste heat is released into the environment by the downstream re-cooling module.

[0018] Preferably, the changeover valve can be opened and closed in several stages, preferably continuously. As a result, and possibly in conjunction with the otational speed control of the fans of the re-cooling modules, it is also possible, depending on the respective temperature situation, to realize only partial heat recovery into the interior of the building in order to maximize heat recovery.

[0019] Heat recovery into the interior of the building via the re-cooling device is not limited to the free cooling mode, but can also be achieved when the compression refrigerating machine (chiller) is operating in a cooling support mode or a partial load mode. A two-stage compression refrigerating machine (chiller) that works with a water-based refrigerant (e.g. the chiller described in DE 10 2017 115 903 A1), which has several operating modes that are graduated in terms of the amount of cold produced, is particularly suitable for this purpose. Depending on the costs of the external energy supply for heating the industrial buildings, it may even be more economical with such a refrigeration machine to operate the refrigeration machine in partial load mode instead of free cooling mode if the waste heat generated in the cooling circuit of the re-cooling device, which is "purchased" by the electrical energy required to operate the compressor and any peripheral components such as pumps, can be used as a substitute for heating energy (e.g. from a gas heater). In this case, it may also be conceivable to switch off the first re-cooling module, which cools the outside environment, completely or partially, for example by providing an additional switching valve in order to maximize the heat input into the interior of the building via the second re-cooling module.

[0020] The invention then also relates to a refrigeration system, preferably for an industrial process or an industrial machine, with a single-stage or two-stage compression refrigerating machine (chiller), which preferably operates with a water-based refrigerant as described above, and a re-cooling device according to the invention, the cooling water circuit of which is connected to a heat exchanger of the compression refrigerating machine (chiller) and/or a free-cooling heat exchanger.

[0021] In the following, the invention is described further with reference to the accompanying drawings. These show:

Fig. 1 a hydraulic diagram of a re-cooling device according to a first embodiment of the invention,

Fig. 2 a hydraulic diagram of a re-cooling device according to a second embodiment of the invention,

Fig. 3 a hydraulic diagram of a re-cooling device according to a third embodiment of the invention, and

Fig. 4 a hydraulic diagram of a re-cooling device according to a fourth embodiment of the invention.

[0022] The re-cooling device according to the first embodiment of the invention shown schematically in Fig. 1 is shown as part of a refrigeration system in conjunction with a schematically indicated compression refrigeration machine (chiller) 1, which is a completely factory-made refrigeration machine in which all refrigerant-carrying components are combined to form a functional circuit. The transfer of the cold generated in the refrigeration process in the refrigeration machine 1, which is mechanically driven by a compressor, typically takes place via a first heat exchanger 2, which is thermally associated with the evaporator of the refrigeration machine. The heat generated in the refrigeration process is dissipated via a second heat exchanger 3, which is assigned to the condenser of the refrigeration machine. Due to the heat transfer by means of the heat exchanger, the internal refrigerant circuit of the chiller is materially decoupled from the external refrigerant lines of the refrigeration system.

[0023] An example of a refrigeration machine suitable for the purposes of the present invention is the heat pump system described in DE 10 2017 115 903 A1, which operates with a water-based refrigerant. The disclosure of this publication is included for the purposes of the details of the refrigeration machine, it being noted that the refrigeration machine and its internal components as such are of secondary importance for the purposes of the present invention and that other refrigeration machines or chillers can also be used.

[0024] The refrigeration system then comprises the re-cooling device 4, which is hydraulically connected to the corresponding heat exchanger 3, for removing the heat of the refrigeration circuit to the environment, and a free-cooling device 5, which is coupled to the re-cooling device 4 (here via a free-cooling heat exchanger 5a), in order to use the re-cooling device 4 also for direct heat removal of the waste heat from the industrial process or the industrial machine, bypassing the refrigeration machine 1. In this type of free cooling or winter operation or transitional operation, mechanical cooling by the chiller is not or only partially required because the cold from the ambient air can be used for cooling in whole or in part. By switching off or throttling the refrigerating machine (compressor) and any other components that are not required, the supply of external electrical energy can be reduced, thereby increasing the overall efficiency of the refrigeration system.

[0025] With the exception of the fourth embodiment, the details of the cold water side of the refrigerating machine are not particularly important for the purposes of the invention, which is why the corresponding components are not described in detail here and these can be designed as known in the prior art.

[0026] The cooling water circuit 12 of the re-cooling device 4 comprises, in a manner known per se, a preferably rotational speed-controlled re-cooling module or unit 4a with one or more fans or ventilators/ventilators, which is connected to the outlet of the heat exchanger 3 via a cooling water feed flow 4b and which is connected to the inlet of the heat exchanger 3 via a cooling water return flow 4c. A preferably rotational speed-controlled cooling water circulation pump 4d is arranged in the return flow 4c of the re-cooling device 4 (a bypass valve 4e is inserted into the return flow upstream of the circulation pump 4d in order to feed cooling medium directly from the feed flow 4b to the return flow 4c via a bypass line 4f, bypassing the re-cooling module 4a). The bypass valve 4e is preferably a variably controllable 3-way valve.

[0027] As re-cooling modules, known re-cooling modules with plural, preferably a pair of axial fans or ventilators can be used, whereby the fans or ventilators are preferably controllable as to their rotational speed, whereby their number can also be 1 or more than two or other types of fans or ventilators can be used. The terms also commonly used in the prior art, such as free cooler, dry cooler, table cooler, air-cooled brine cooler, re-cooling unit, are understood for the purposes of the disclosure to be synonymous with the term "re-cooling module or unit". For the heat transfer medium in the closed cooling water circuit, any suitable heat transfer fluids can also be used. In this respect, the terms "cooling medium", "cold water" and "cooling water" or "coolant" in the context of the present disclosure of the invention are not to be interpreted as being limited to a specific heat transfer fluid, in particular "water" or a water/glycol mixture, but rather the terms are intended to encompass all suitable liquid heat transfer media for the purpose of heat transport in the respective line circuits.

[0028] The re-cooling device 4 is hydraulically coupled to the free-cooling heat exchanger 5a, which is designed as a plate heat exchanger, for example, via a variably controllable 3-way valve 4g in order to transfer heat from the return of a cold water circuit to the cooling water circuit of the re-cooling device 4 in free-cooling mode and to discharge the heat to the environment via this circuit (without the need to use and operate the chiller).

[0029] While the re-cooling module(s) 4a representing the first re-cooling module is/are arranged or is/are to be arranged outside a building envelope in a manner known per se in order to be able to transfer heat to the environment, at least one second re-cooling module 6 is provided according to the invention, which is preferably arranged or to be arranged inside a building envelope in order to be able to transfer heat to the interior of the building, the second re-cooling module 6 being connected to the return flow 4c of the cooling water circuit via a changeover valve 7 in such a way that a cooling medium can flow through it selectively. The changeover valve 7 is preferably also a variably controllable 3-way valve.

[0030] In the first embodiment, the first re-cooling module 4a and the second re-cooling module 6 are connected in parallel with respect to the cooling water circuit, with the second re-cooling module 6 being connected to the cooling water feed flow 4b upstream of the first re-cooling module 4a in the direction of flow of the coolant

[0031] Downstream of the second re-cooling module 6, an expansion vessel 8 is connected to the return flow 4c of the cooling water circuit.

[0032] The re-cooling device 4 according to the invention also comprises a control system or controller which is designed to open and close the changeover valve 7 of the second re-cooling module 6 depending on a fixed ambient temperature and/or a predetermined time of year or a predetermined date in the course of the year, so that the second re-cooling module can act as heating support for the interior of the building. Preferably (but not necessarily), the activation of the second re-cooling module 6 coincides with free cooling operation, as this usually requires sufficiently low outside temperatures.

[0033] The current ambient temperature in the area of the second re-cooling module 6 can, for example, be detected via a temperature sensor 9 in the area of the second re-cooling module 6 and supplied to the control system via a signal line (or through the air).

[0034] In a simple control system, the changeover valve 7 of the second re-cooling module 6 can be opened if the temperature detected by the temperature sensor 9 is below the specified outside temperature. Additionally or alternatively, a fixed or calculated date can be specified that indicates the start of a heating period. When the changeover valve is opened, heat is then released from the cooling water circuit of the re-cooling device via the second re-cooling module into the interior of the building envelope, thereby supporting the heating.

[0035] The re-cooling device according to the second embodiment of the invention, shown schematically in Fig. 2, differs from the first embodiment in that the first re-cooling module and the second re-cooling module are not connected in parallel with respect to the cooling water circuit, but in series. Specifically and preferably, the second re-cooling module is arranged in the cooling water circuit upstream of the first re-cooling module and is flowed through first in order to dissipate a larger amount of heat into the interior of the building. The other features of the re-cooling device correspond to those of the first embodiment.

[0036] With this arrangement - in addition to the heating support as in the first embodiment - a higher heat exchanger surface area (double in the case of two identical re-cooling modules) can be provided with a lower gradient to the outside temperature, because the re-cooling module downstream in the series connection only has to deliver a lower output. As a result, the duration of free cooling operation can be extended when operating two re-cooling modules and corresponding energy savings can be realized with a positive effect on the efficiency of the cooling system. By increasing the heat exchanger surface of the re-cooling modules with serial flow, the rotational speed of the respective fans or ventilators or blowers installed in the re-cooling modules can be modulated and reduced depending on the ambient temperature detected (provided they can be speed-controlled), which leads to a reduction in power consumption, since - with the same volume flow - for example 4 fans in 2 modules at reduced rotational speed have a lower power consumption than 2 fans of a single module at full rotational speed.

[0037] A typical, but merely exemplary, temperature distribution at a waste heat of 26°C is a reduction of the temperature from 26°C to 24°C in the second re-cooling module 6 and from 24°C to 22°C in the first re-cooling module 4a, so that free cooling can take place up to a temperature of 20°C if desired.

[0038] The re-cooling device according to the third embodiment of the invention, shown schematically in Fig. 3, differs from the first embodiment in that the first re-cooling module (which is arranged outside the building envelope and cools with respect to the outside air) can be switched off and the system operation serves exclusively to heat the building. This re-cooling module is therefore only shown shaded. It can be switched off via a changeover valve (not shown). For example, free cooling can only be operated with the indoor re-cooling module 6 up to a temperature of around 16°C - 17°C if the target temperature of the building (hall) is greater than 20°C, for example. In this situation, it may even be economical to run this operating mode of the re-cooling device not only with free cooling, but also with at least partial load operation of the chiller, if the heat input into the building by the re-cooling device, which supports the heating, can achieve a corresponding reduction in heating energy using a comparatively expensive energy source such as gas or oil.

[0039] The system shown schematically in Fig. 4 according to the fourth embodiment of the invention differs from the first to third embodiments in that the second re-cooling module 6a, which is preferably arranged or to be arranged within the building envelope, to dissipate heat to the interior of the building, is connected via a changeover valve 10 to a return 11 of a cold water circuit, which is connected or is to be connected to a heat exchanger 2 of the compression refrigeration machine (chiller) 1, in such a way that a coolant can flow through it selectively. By integrating the re-cooling module in the return flow on the cold water side, waste heat is generally always available, which can be introduced into the interior of the building for heating support.

[0040] A typical, but merely exemplary, temperature distribution with a waste heat of 27°C is a reduction of the temperature from 27°C to 25°C in the second re-cooling module 6a and from 25°C to 23°C in the evaporator-side heat exchanger 2 of the refrigeration machine 1, through which the heat flows in series.

[0041] While the first to fourth embodiments have been illustrated and described separately and independently of one another with regard to their different aspects, a combination of these different aspects in a common refrigeration system is also conceivable. For example, the re-cooling module 6a integrated on the cold water side in the fourth embodiment can also be combined with the serial or parallel arrangement of a first re-cooling module (that is arranged on the outside of the building) and a second re-cooling module (that is arranged on the inside of the building) in the re-cooling device on the cooling water side as in the first and second embodiments and, if desired, with the first re-cooling module (then arranged on the inside of the building) being capable of being switched off as in the third embodiment in order to maximize the heat input into the interior of the building to support the heating system and maximize the overall efficiency ratio.

Claims

1. A re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, comprising

   a cooling water circuit (12) connected or to be connected to a heat exchanger (3) of a compression refrigeration machine (chiller) (1) and/or a free-cooling heat exchanger (5a),

   a first re-cooling module (4a), which is connected to the cooling water circuit (12) and is preferably arranged or to be arranged outside a building envelope in order to be able to dissipate heat to the environment,

a second re-cooling module (6), which is preferably arranged or to be arranged inside a building envelope in order to be able to dissipate heat to the interior of the building, the second re-cooling module (6) being connected to the cooling water circuit (12) via a changeover valve (7) in such a way that a cooling medium can flow through it selectively, and

a control system which is designed to open and close the changeover valve (7) of the second re-cooling module (6) as a function of a predetermined outside temperature and/or a predetermined time of year.

2. The re-cooling device according to claim 1, wherein the first re-cooling module (4a) and the second re-cooling module (6) are connected in parallel with respect to the cooling water circuit (12).

3. The re-cooling device according to claim 1, wherein the first re-cooling module (4a) and the second re-cooling module (6) are connected in series with respect to the cooling water circuit (12).

4. The re-cooling device according to claim 3, wherein the second re-cooling module (6) is arranged in the cooling water circuit (12) upstream of the first re-cooling module (6).

5. The re-cooling device according to any one of claims 1 to 4, wherein a third re-cooling module (6a), which is preferably arranged or to be arranged inside a building envelope in order to dissipate heat to the building interior, is connected via a changeover valve (10) to a return (11) of a cold water circuit, which is connected or to be connected to a heat exchanger (2) of the compression refrigeration machine (chiller) (1), such that a cooling medium can selectively flow through it.

6. A re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, comprising:

a cooling water circuit (12) which is connected or to be connected to a heat exchanger (3) of a compression refrigeration machine (chiller) (1) and/or a free-cooling heat exchanger (5a),

a first re-cooling module (4a), which is connected to the cooling water circuit (12) and is preferably arranged or to be arranged outside a building envelope in order to be able to dissipate heat to the environment,

a second re-cooling module (6a), which is preferably arranged or to be arranged inside a building envelope in order to dissipate heat to the interior of the building, the second re-cooling module (6a) being connected via a changeover valve (10) to a return (11) of a cold water circuit, which is connected or to be connected to a heat exchanger (2) of the compression refrigeration machine (chiller) (1), in such a way that a cooling medium can flow through it selectively, and

a control system which is designed to open and close the changeover valve (10) of the second re-cooling module (6a) as a function of a predetermined outside temperature and/or a predetermined season.

7. The re-cooling device according to one of claims 1 to 6, wherein the changeover valve (7;10) is configured such that it can be opened and closed in several stages, preferably steplessly.

8. The re-cooling device according to one of claims 1 to 7, wherein the re-cooling modules (4a;6;6a) each have a fan, which is preferably adjustable in rotational speed.

9. A refrigeration system, preferably for an industrial process or an industrial machine, comprising

a single-stage or two-stage compression refrigeration machine (chiller) (1), which preferably operates with a water-based refrigerant, and

a re-cooling device according to any one of claims 1 to 8, the cooling water circuit (12) of which is connected to a heat exchanger (3) of the compression refrigeration machine (chiller) (1) and/or a free-cooling heat exchanger (5a).

10. A method for controlling a re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, which comprises

a cooling water circuit (12) connected to a heat exchanger (3) of a compressor refrigeration machine (chiller) (1) and/or a free-cooling heat exchanger (5a),

a first re-cooling module (4a), which is connected to the cooling water circuit (12) and is preferably arranged outside a building envelope in order to be able to dissipate heat to the environment, and

a second re-cooling module (6), which is preferably arranged inside a building envelope in order to be able to dissipate heat to the interior of the building, the second re-cooling module (6) being connected to the cooling water circuit (12) via a changeover valve (7) in such a way that a cooling medium can flow through it selectively, wherein the changeover valve (7) of the second re-cooling module (6) is opened and closed depending on a predetermined outside temperature and/or a predetermined season in order to dissipate heat to the interior of the building.

11. The method according to claim 10, wherein the first re-cooling module (4a) and the second re-cooling module (6) are connected in parallel with respect to the cooling water circuit (12).

12. The method according to claim 10, wherein the first re-cooling module (4a) and the second re-cooling module (6) are connected in series with respect to the cooling water circuit (12).

13. The method according to claim 12, wherein the second re-cooling module (6) is arranged in the cooling water circuit (12) upstream of the first re-cooling module (4a).

14. A method for controlling a re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, comprising

a cooling water circuit (12) connected to a heat exchanger (3) of a compression refrigeration machine (chiller) (1) and/or a free-cooling heat exchanger (5a),
a first re-cooling module (4a), which is connected to the cooling water circuit (12) and is preferably arranged outside a building envelope in order to be able to dissipate heat to the environment, and
a second re-cooling module (6a), which is preferably arranged inside a building envelope in order to be able to dissipate heat to the interior of the building, the second re-cooling module (6a) being connected via a changeover valve (10) to a return (11) of a cold water circuit, which is connected to a heat exchanger (2) of the compression refrigeration machine (chiller) (1), in such a way that a cooling medium can flow through it selectively,
wherein the changeover valve (10) of the second re-cooling module (6a) is opened and closed depending on a predetermined outdoor temperature and/or a predetermined season in order to release heat to the interior of the building.

15. The method according to any one of claims 10 to 14, wherein the switching valve (7;10) is opened and closed in several stages, preferably steplessly.

16. The method according to one of claims 10 to 15, wherein the re-cooling modules (4a;6;6a) each have a fan, which is preferably speed-controlled in each case.

17. The method according to any one of claims 10 to 16, wherein the compression refrigeration machine (chiller) (1) is a single-stage or two-stage refrigeration machine (chiller), which preferably operates with a water-based refrigerant.

Amended claims in accordance with Rule 137(2) EPC.

1. A re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, comprising

a cooling water circuit (12) connected or to be connected to a heat exchanger (3) of a compression refrigeration machine (1) and a free-cooling heat exchanger (5a) or to a free-cooling heat exchanger (5a),
a first re-cooling module (4a), which is connected to the cooling water circuit (12) and is arranged or to be arranged outside a building envelope in order to be able to dissipate heat to the environment,
a second re-cooling module (6), which is arranged or to be arranged inside a building envelope in order to be able to dissipate heat to the interior of the building, the second re-cooling module (6) being connected to the cooling water circuit (12) via a changeover valve (7) in such a way that a cooling medium can flow through it selectively, and
a control system which is designed to open and close the changeover valve (7) of the second re-cooling module (6) as a function of a predetermined outside temperature and/or a predetermined time of year.

2. The re-cooling device according to claim 1, wherein the first re-cooling module (4a) and the second re-cooling module (6) are connected in parallel with respect to the cooling water circuit (12).

3. The re-cooling device according to claim 1, wherein the first re-cooling module (4a) and the second re-cooling module (6) are connected in series with respect to the cooling water circuit (12).

4. The re-cooling device according to claim 3, wherein the second re-cooling module (6) is arranged in the cooling water circuit (12) upstream of the first re-cooling module (6).

5. The re-cooling device according to any one of claims 1 to 4, wherein a third re-cooling module (6a), which is preferably arranged or to be arranged inside a building envelope in order to dissipate heat to the building interior, is connected via a changeover valve (10) to a return (11) of a cold water circuit, which is connected or to be connected to a heat exchanger (2) of the compression refrigeration machine (1), such that a cooling medium can selectively flow through it.

6. A re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, comprising:

a cooling water circuit (12) which is connected or to be connected to a heat exchanger (3) of a compression refrigeration machine (1) and a free-cooling heat exchanger (5a) or to a free-cooling heat exchanger (5a),
a first re-cooling module (4a), which is connected to the cooling water circuit (12) and is arranged or to be arranged outside a building envelope in order to be able to dissipate heat to the environment,
a second re-cooling module (6a), which is arranged or to be arranged inside a building envelope in order to dissipate heat to the interior of the building, the second re-cooling module (6a) being connected via a changeover valve (10) to a return (11) of a cold water circuit, which is connected or to be connected to a heat exchanger (2) of the compression refrigeration machine (1), in such a way that a cooling medium can flow through it selectively, and
a control system which is designed to open and close the changeover valve (10) of the second re-cooling module (6a) as a function of a predetermined outside temperature and/or a predetermined season.

7. The re-cooling device according to one of claims 1 to 6, wherein the changeover valve (7;10) is configured such that it can be opened and closed in several stages, preferably steplessly.

8. The re-cooling device according to one of claims 1 to 7, wherein the re-cooling modules (4a;6;6a) each have a fan, which is preferably adjustable in rotational speed.

9. A refrigeration system, preferably for an industrial process or an industrial machine, comprising

a single-stage or two-stage compression refrigeration machine (1), which preferably operates with a water-based refrigerant and has a heat exchanger (3), and
a re-cooling device according to any one of claims 1 to 8, the cooling water circuit (12) of which is connected to the heat exchanger (3) of the compression refrigeration machine (1) and the free-cooling heat exchanger (5a).

10. A method for controlling a re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, which comprises

a cooling water circuit (12) connected to a heat exchanger (3) of a compressor refrigeration machine (chiller) (1) and a free-cooling heat exchanger (5a) or to a free-cooling heat exchanger (5a),
a first re-cooling module (4a), which is connected to the cooling water circuit (12) and is arranged outside a building envelope in order to be able to dissipate heat to the environment, and
a second re-cooling module (6), which is arranged inside a building envelope in order to be able to dissipate heat to the interior of the building, the second re-cooling module (6) being connected to the cooling water circuit (12) via a changeover valve (7) in such a way that a cooling medium can flow through it selectively,
wherein the changeover valve (7) of the second re-cooling module (6) is opened and closed depending on a predetermined outside temperature and/or a predetermined season in order to dissipate heat to the interior of the building.

11. The method according to claim 10, wherein the first re-cooling module (4a) and the second re-cooling module (6) are connected in parallel with respect to the cooling water circuit (12).

12. The method according to claim 10, wherein the first re-cooling module (4a) and the second re-cooling module (6) are connected in series with respect to the cooling water circuit (12).

13. The method according to claim 12, wherein the second re-cooling module (6) is arranged in the cooling water circuit (12) upstream of the first re-cooling module (4a).

14. A method for controlling a re-cooling device for a refrigeration system, preferably for an industrial process or an industrial machine, comprising

a cooling water circuit (12) connected to a heat exchanger (3) of a compression refrigeration machine (1) and a free-cooling heat exchanger (5a) or to a free-cooling heat exchanger (5a),
a first re-cooling module (4a), which is connected to the cooling water circuit (12) and is arranged outside a building envelope in order to be able to dissipate heat to the environment, and
a second re-cooling module (6a), which is arranged inside a building envelope in order to be

able to dissipate heat to the interior of the building, the second re-cooling module (6a) being connected via a changeover valve (10) to a return (11) of a cold water circuit, which is connected to a heat exchanger (2) of the compression refrigeration machine (1), in such a way that a cooling medium can flow through it selectively, wherein the changeover valve (10) of the second re-cooling module (6a) is opened and closed depending on a predetermined outdoor temperature and/or a predetermined season in order to release heat to the interior of the building.

15. The method according to any one of claims 10 to 14, wherein the switching valve (7;10) is opened and closed in several stages, preferably steplessly.

16. The method according to one of claims 10 to 15, wherein the re-cooling modules (4a;6;6a) each have a fan, which is preferably speed-controlled in each case.

17. The method according to any one of claims 10 to 16, wherein the compression refrigeration machine (1) is a single-stage or two-stage refrigeration machine, which preferably operates with a water-based refrigerant.

Fig. 1

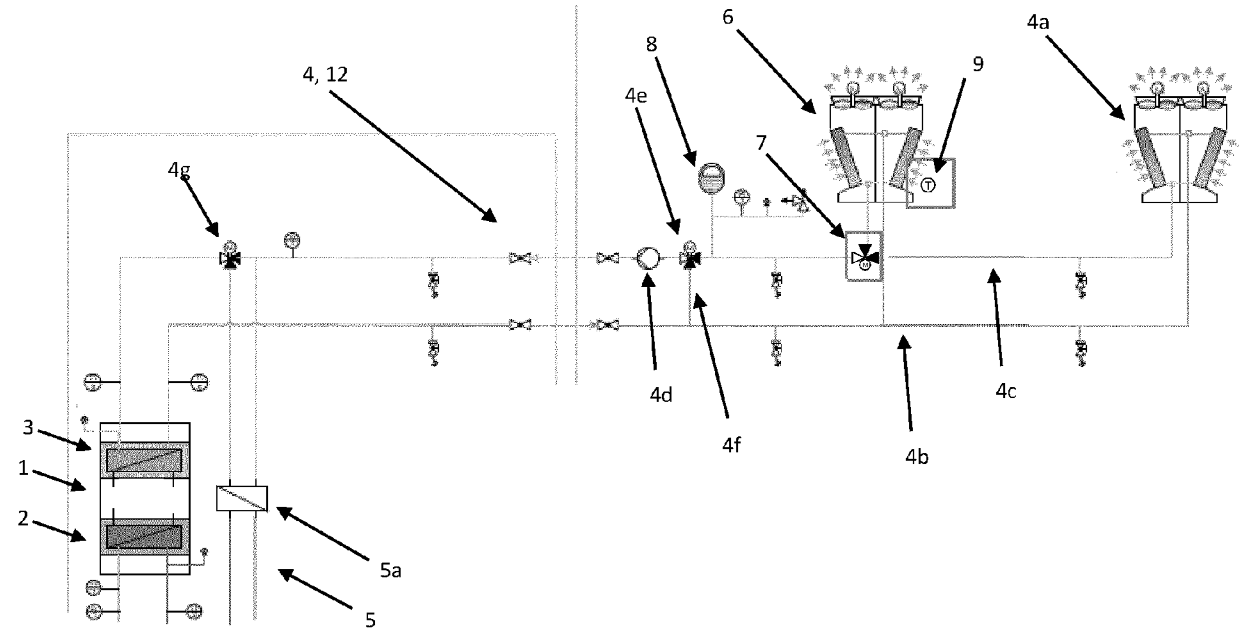


Fig. 2

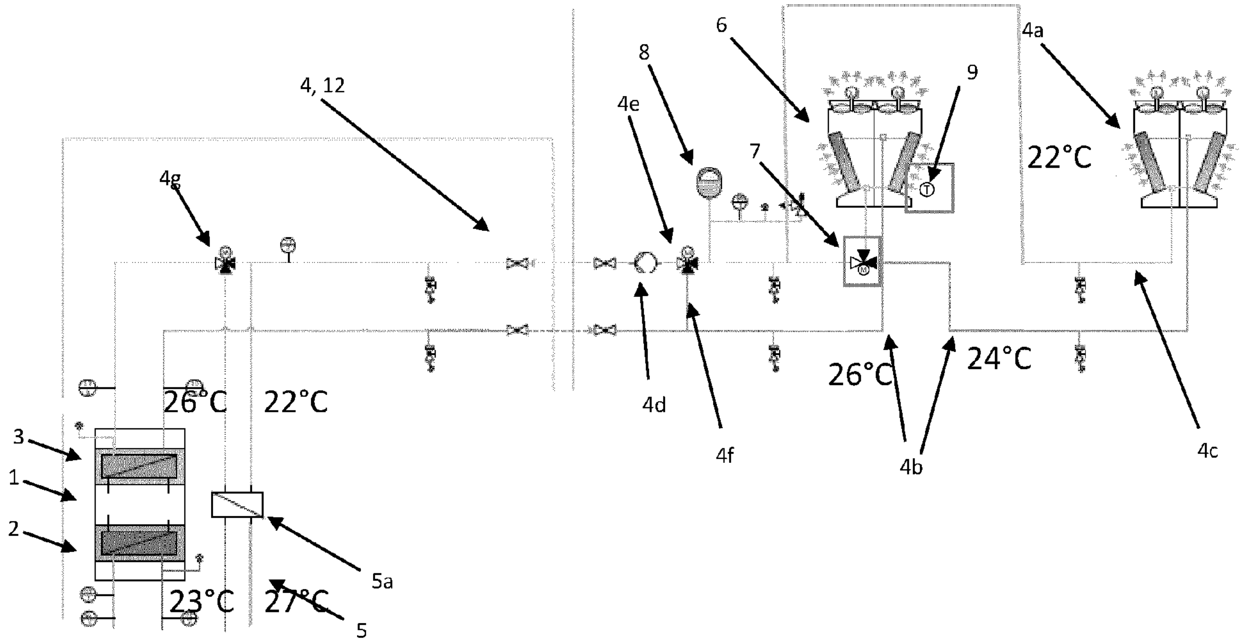
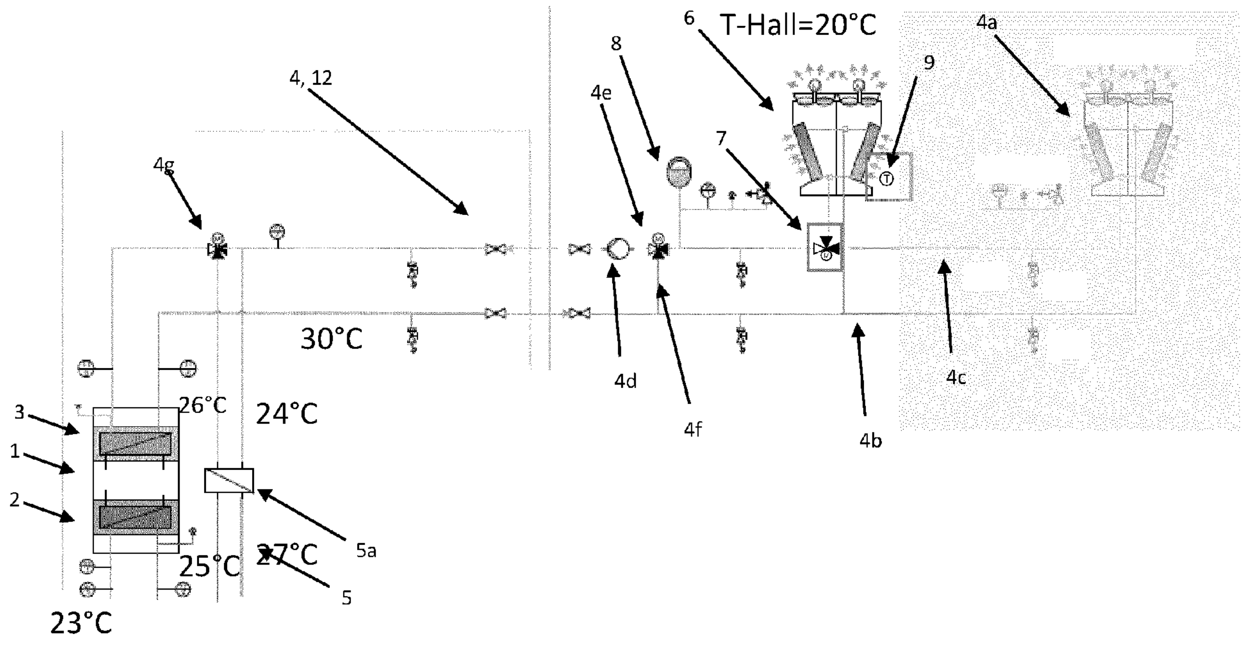


Fig. 3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4a
9
8
4e
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4, 12
4g
30°C
4d
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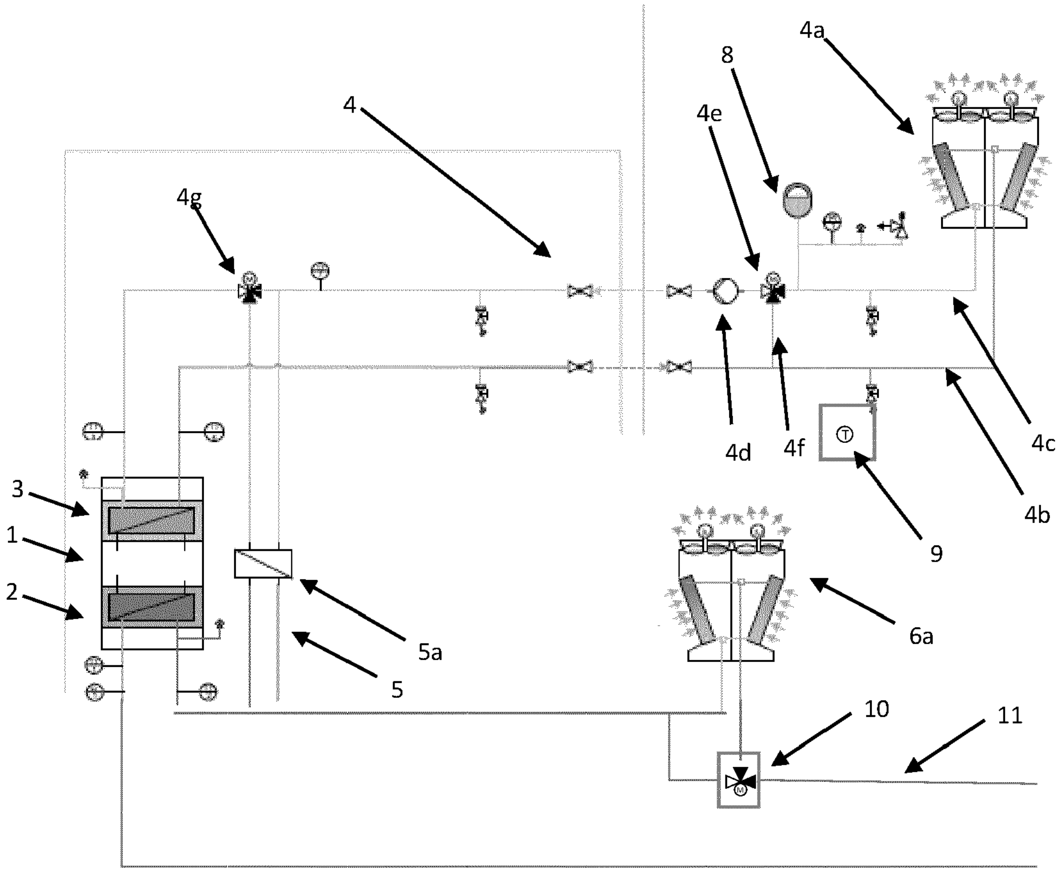
5
23°C

Fig. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 23 22 0354

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 203 518 141 U (UNIV TSINGHUA) 2 April 2014 (2014-04-02)	1,2,5, 7-11, 15-17	INV. F25B25/00 F25B49/02
Y	* paragraphs [0002] - [0008]; figure 1 *	3,4,12, 13	
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Y	* paragraphs [0054] - [0073]; figures 5-12 * -----	3,4,12, 13	TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 April 2024	Weisser, Meinrad

CATEGORY OF CITED DOCUMENTS

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