(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
19 December 2024 (19.12.2024)

WIPO | PCT

(10) **International Publication Number**
WO 2024/258041 A1

(51) **International Patent Classification:**
B60H 1/32 (2006.01) ***B60H 1/14*** (2006.01)
B60H 1/00 (2006.01) ***F25B 40/00*** (2006.01)

(21) **International Application Number:** PCT/KR2024/005573

(22) **International Filing Date:** 25 April 2024 (25.04.2024)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
10 2023 115 550.4 14 June 2023 (14.06.2023) DE
10 2024 105 652.5 28 February 2024 (28.02.2024) DE

(71) **Applicant: HANON SYSTEMS** [KR/KR]; 95, Sinilseo-ro, Daedeok-gu, Daejeon 34325 (KR).

(72) **Inventor: HEYL, Peter**; Kornradenweg 90, 50999 Köln (DE).

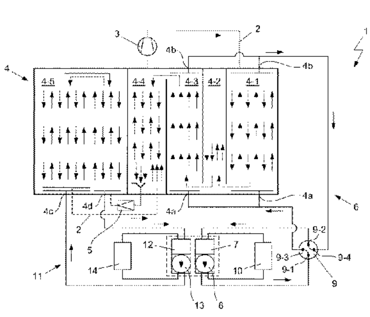
(74) **Agent: HONESTY & JR PARTNERS INTELLECTUAL PROPERTY LAW GROUP**; 5F, 615 Sunreung-ro, Gangnam-gu, Seoul 06103 (KR).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** HEAT MANAGEMENT SYSTEM AND METHOD FOR OPERATING A HEAT MANAGEMENT SYSTEM



(57) **Abstract:** The invention relates to a heat management system (1) for a motor vehicle with a refrigerant circuit (2), each with a refrigerant-coolant heat exchanger operated as a condenser/gas cooler (4-1) and a refrigerant-coolant heat exchanger operated as a sub-cooler (4-3) and a high-temperature refrigerant circuit (6) with a coolant unit (7) and a conveying device (8). The high-temperature coolant circuit (6) is formed with a switching means such that the coolant circulating in the high-temperature coolant circuit (6) flows through the condenser/gas cooler (4-1) and the sub-cooler (4-3) in the same direction as at least two coolant partial mass flows which are guided parallel to one another. The flow directions of the refrigerant through the condenser/gas cooler (4-1) and the sub-cooler (4-3) are orientated in opposite directions to one another. The switching means of the high-temperature coolant circuit (6) can be adjusted between two switching positions in order to conduct the coolant as required. The invention also relates to a method for operating the heat management system (1) for conditioning a supply air of a passenger compartment in different operating modes.

WO 2024/258041 A1

Description

Title of Invention: HEAT MANAGEMENT SYSTEM AND METHOD FOR OPERATING A HEAT MANAGEMENT SYSTEM

Technical Field

[1] The invention relates to a heat management system for a motor vehicle with a refrigerant circuit and a high-temperature coolant circuit. The refrigerant circuit has a refrigerant-coolant heat exchanger operated as a condenser/gas cooler and a refrigerant-coolant heat exchanger operated as a sub-cooler, which are formed as components of the high-temperature coolant circuit, so that the refrigerant circuit and the high-temperature coolant circuit are thermally coupled to one another via the refrigerant-coolant heat exchangers.

[2] The invention also relates to a method for operating the heat management system for a motor vehicle for conditioning the supply air of a passenger compartment in a refrigeration system mode, in particular for cooling and/or dehumidifying the supply air, and in a heating mode, in particular for heating the supply air of the passenger compartment.

Background Art

[3] Motor vehicles with different drive concepts are known from the state of the art. The concepts are based on drives by means of a fuel cell, a combustion engine, an electric motor or a combination of both motor types, for example. Consequently, motor vehicles with a combination of an internal combustion engine and an electric motor drive have a hybrid drive so that the motor vehicle can be driven electrically, electrically/with an internal combustion engine or with an internal combustion engine as required.

[4] As is known, electric vehicles and vehicles with a hybrid drive and fuel cell vehicles and vehicles driven with an internal combustion engine with high energetic efficiency do not create enough waste heat in order to heat the passenger compartment at low ambient temperatures corresponding to the requirements of thermal comfort.

[5] In addition to the waste heat from the engine, an air-conditioning system with a heat pump function offers, in addition to operation in a refrigeration system mode, a possibility for heating the supply air for the passenger compartment. The air-conditioning system uses different heat sources and heat sinks.

[6] When operating the air-conditioning system of a motor vehicle in the refrigeration system mode for cooling the supply air of the passenger compartment or a coolant circulating in a coolant circuit, in particular when operating a refrigerant circuit of

the air-conditioning system with an evaporator and a condenser/gas cooler of the refrigerant, the heat required for the evaporation of the refrigerant is absorbed at a lower temperature level and pressure level in the evaporator from the supply air to the passenger compartment or from a coolant circuit, also referred to as a low-temperature coolant circuit, respectively as a heat source. The coolant circuit can be used, for example, for cooling components of the electric drive train, such as a traction battery, an internal charger, a transformer, an inverter or a drive motor, of an electrically driven motor vehicle. The heat absorbed by the refrigerant can be transferred at a higher temperature level and pressure level to a heat sink, such as the ambient air or a coolant circuit, also referred to as a high-temperature coolant circuit, in addition to a power supplied in a compressor of the refrigerant circuit in the condenser/gas cooler.

[7] When the air-conditioning system, in particular the refrigerant circuit of the air-conditioning system with heat pump function, is operated in a heating mode for heating the supply air for the passenger compartment, the heat required for vaporising the refrigerant is taken up at the low-temperature level and pressure level in the evaporator from a heat source, such as the ambient air or the refrigerant circuit, in particular the low-temperature coolant circuit. In the condenser/gas cooler, the heat taken up by the refrigerant plus the power supplied in the compressor of the refrigerant circuit can be discharged to a heat sink at a higher temperature level and pressure level, in particular the supply air for the passenger compartment or the coolant circuit. In doing so, the coolant circuit can be used, in particular, for heating components of the electric drive train of the electrically driven motor vehicle.

[8] Depending on the operating mode of the air-conditioning system, the heat can also be transferred from the coolant circulating in the coolant circuit, especially the high-temperature coolant circuit, to the supply air for the passenger compartment or from the supply air for the passenger compartment to the coolant circulating in the coolant circuit, especially the low-temperature coolant circuit, in order to heat or cool and/or dehumidify the supply air for the passenger compartment.

[9] If the refrigerant is liquefied with carbon dioxide during subcritical operation of the refrigerant circuit, such as with the refrigerant R134a, R1234yf, R290 or R152a, or under certain ambient conditions, the heat exchanger is referred to as a condenser. Part of the heat transfer takes place at a constant temperature. During supercritical operation or supercritical heat release in the heat exchanger, the temperature of the refrigerant decreases continuously. In this case, the heat exchanger is also referred to as gas cooler. Supercritical operation may occur under certain ambient conditions or modes of operation of the refrigerant circuit, for example, with the refrigerant carbon dioxide.

[10] DE 10 2021 113 104 A1 discloses a thermal management arrangement for a motor vehicle with a refrigerant circuit and two coolant circuits. The refrigerant circuit has at least one compressor, a condenser/gas cooler, an expansion member and an evaporator. A first coolant circuit, also referred to as a refrigeration carrier circuit, is thermally coupled via the evaporator and a second coolant circuit, also referred to as a heat carrier circuit, is thermally coupled via the condenser/gas cooler in each case to the refrigerant circuit.

[11] Conventional systems with at least one refrigerant circuit and several coolant circuits have a plurality of, in addition, large-volume heat exchangers in order to meet all the requirements placed on the system with regard to the air conditioning of the passenger compartment and the temperature control of various components of the, in particular, electric drive train. With the fulfilment of various functions, moreover, the number of components which are necessarily to be integrated in the motor vehicle increases. In this case, the installation space of the motor vehicle is limited.

[12] DE 10 2018 129 988 A1 discloses a compact heat exchanger unit for air-conditioning systems in motor vehicles for a liquid-cooled condensation of refrigerant of a refrigerant circuit, storage and sub-cooling of the liquid refrigerant and evaporation of the refrigerant. A condenser region, a high-pressure refrigerant collector region, a sub-cooling region and an evaporator region for the refrigerant, especially in the form of respective plate packs, are formed in a combined manner within a one-piece heat exchanger, in particular a plate heat exchanger.

[13] In combined air-conditioning systems for heating and cooling, in particular the supply air of the passenger compartment of the motor vehicle, the conditions, in particular within the compact heat exchanger unit, are very different for the different operating modes. For example, on the one hand, the sub-cooling of the refrigerant following the condensation during operation of the air-conditioning system in the refrigeration system mode should be at most in the range from 8 K to 12 K. Higher sub-cooling leads to an energetically inefficient operation of the air-conditioning system. On the other hand, the energetic efficiency of the air-conditioning system is improved when the air-conditioning system is operated in the heating mode with a higher sub-cooling of the refrigerant. Further influencing factors are the required heat outputs and the required temperature levels for the absorption of heat by the refrigerant or for the release of heat from the refrigerant.

[14] The liquid-cooled heat exchangers known from the prior art for condensing and sub-cooling the refrigerant are operated in the sub-cooling region of the refrigerant in the parallel flow of refrigerant and coolant. The parallel flow of the fluids in this case causes a lower sub-cooling of the refrigerant at the outlet of the heat exchanger than, for example, a guiding of the fluids in a counterflow.

Disclosure of Invention

Technical Problem

[15] The object of the invention is to provide a heat management system which is also simple to assemble due to a low complexity and a minimum number of components and whose components are easy to replace, in particular for repair purposes. The heat management system should also have components which have a minimum installation space. The heat transfer in heat-transferring components of the refrigerant circuit and the coolant circuit should be at maximum, and temperature differences of the fluids which can be achieved with the heat transfer should be adaptable, in particular also in the case of different operating modes of the heat management system.

Solution to Problem

[16] The object is achieved by the subject matters having the features of the independent claims. Further developments are specified in the dependent claims.

[17] The object is achieved by a heat management system according to the invention for a motor vehicle having a refrigerant circuit and a high-temperature coolant circuit. The refrigerant circuit has a refrigerant-coolant heat exchanger operated as a condenser/gas cooler and a refrigerant-coolant heat exchanger operated as a sub-cooler for the refrigerant. The high-temperature coolant circuit is formed with a first coolant unit with a coolant reservoir and, if necessary, coolant valves and a first conveying device for conveying a coolant.

[18] A heat management system is to be understood here as meaning an arrangement or a device with several components and their control means and regulating means, which ensures the supply of heat or cold, in particular, to a motor vehicle. The system is connected to various heat sources and heat sinks, for example, heat can be transferred from the system to ambient air, supply air of the passenger compartment or components of a drive train as required, or heat can be transferred from the ambient air, the supply air of the passenger compartment or components of the drive train to the system. The heat absorbed by the system can be used, in particular at appropriate temperature levels, for heating the supply air of the passenger compartment or of components of the drive train. In this case, the heat can also be absorbed from the supply air of the passenger compartment or from components of the drive train.

[19] The high-temperature coolant circuit is formed in such a way that the coolant circulating in the high-temperature coolant circuit flows through the condenser/gas cooler and the sub-cooler in the same direction as at least two coolant partial mass flows conducted parallel to one another. The flow directions of the refrigerant through the condenser/gas cooler and the sub-cooler are aligned opposite to one another.

[20] According to the concept of the invention, the high-temperature coolant circuit has a switching means of the flow direction of the coolant through the condenser/gas cooler and the sub-cooler, which is configured such that, in a first switching position of the switching means, the coolant flows in a counter-current to the refrigerant through the condenser/gas cooler and in a co-current to the refrigerant through the sub-cooler and in a second switching position of the switching means, the coolant flows in a co-current to the refrigerant through the condenser/gas cooler and in a counter-current to the refrigerant through the sub-cooler.

[21] Thus, depending on the switching position of the switching means, the refrigerant and the coolant partial mass flows can, on the one hand, act on the condenser/gas cooler in a counter-current and on the sub-cooler in a co-current and, on the other hand, act on the condenser/gas cooler in a co-current and on the sub-cooler in a counter-current.

[22] According to a further development of the invention, the condenser/gas cooler and the sub-cooler are formed as a single unit within a heat exchanger unit. The heat exchanger unit has at least one first coolant connection and at least one second coolant connection, to which the condenser/gas cooler and the sub-cooler of the coolant circuit are integrated into the high-temperature coolant circuit.

[23] According to an advantageous design of the invention, the high-temperature coolant circuit has a valve arrangement as a switching means of the flow direction of the coolant, which is configured such that, in the first switching position, the coolant is conducted from the conveying device to the first coolant connection of the heat exchanger unit operated as an inlet and from the second coolant connection of the heat exchanger unit operated as an outlet to the coolant unit and, in the second switching position, the coolant is conducted from the conveying device to the second coolant connection of the heat exchanger unit operated as an inlet and from the first coolant connection of the heat exchanger unit operated as an outlet to the coolant unit.

[24] When the coolant partial mass flows flow through the condenser/gas cooler and the sub-cooler in a rectified manner, the coolant either flows through the first coolant connection into the heat exchanger unit, in particular the condenser/gas cooler and the sub-cooler, and out of the heat exchanger unit through the second coolant connection, or the coolant flows through the second coolant connection into the heat exchanger unit, in particular the condenser/gas cooler and the sub-cooler, and out of the heat exchanger unit through the first coolant connection.

[25] According to a further development of the invention, the valve arrangement is formed as a 4/2-way valve with connections for integration into the high-temperature coolant circuit. A first connection as an inlet is connected to the first conveyor device via a connecting line, a second connection as an outlet is connected to the first

coolant unit via a connecting line, a third connection is connected to the first coolant connection of the heat exchanger unit via a connecting line, and a fourth connection is connected to the second coolant connection of the heat exchanger unit via a connecting line.

[26] The valve arrangement is advantageously configured such that, in a first switching position, the first connection is connected internally to the third connection and the fourth connection is connected to the second connection, and in a second switching position, the first connection is connected internally to the fourth connection and the third connection is connected to the second connection. Thus, in the first switching position, on the one hand, the first connection and the third connection and, on the other hand, the fourth connection and the second connection are each connected to the passage for the coolant.

[27] The condenser/gas cooler and the sub-cooler are preferably in each case formed as plate packets of a heat exchanger combined in a one-piece plate heat exchanger. The sub-cooler is arranged downstream of the condenser/gas cooler in the flow direction of the refrigerant.

[28] According to a preferred design of the invention, the refrigerant circuit has a refrigerant-coolant heat exchanger operated as an evaporator. The evaporator can be integrated within the heat exchanger unit, so that the condenser/gas cooler, the sub-cooler and the evaporator are preferably formed as plate packs combined in the one-piece plate heat exchanger. The evaporator is arranged downstream of the sub-cooler in the flow direction of the refrigerant.

[29] An advantage of the invention is that a low-temperature coolant circuit is provided, in particular with a second coolant unit and a second conveying device. The heat exchanger unit preferably has at least one third coolant connection and at least one fourth coolant connection, to which the evaporator of the coolant circuit is integrated into the low-temperature coolant circuit.

[30] The refrigerant circuit can also be formed with a collector for the refrigerant and a circuit-internal heat exchanger.

[31] The circuit-internal heat exchanger is to be understood as meaning a heat exchanger which serves for the heat transfer from the refrigerant at a level of the high pressure to refrigerant at a level of the low pressure. As such, for example, the liquid refrigerant is further cooled after the condensation or sub-cooling, on the one hand, and the suction gas of a compressor is superheated, on the other hand.

[32] The collector for the refrigerant is arranged in the refrigerant circuit at the level of the high pressure.

[33] The collector for the refrigerant and the circuit-internal heat exchanger can each be integrated within the heat exchanger unit. In this case, the collector and the circuit-

internal heat exchanger can each be formed as a plate pack combined in the one-piece plate heat exchanger. The collector for the refrigerant is preferably arranged in the flow direction of the refrigerant between the condenser/gas cooler and the sub-cooler, and the circuit-internal heat exchanger is preferably arranged in the flow direction of the refrigerant between the sub-cooler and the evaporator.

[34] According to a further preferred design of the invention, the refrigerant circuit has an expansion member and a compressor. The expansion member, in particular an expansion valve, can be integrated within the heat exchanger unit.

[35] The individual heat exchanger regions, in particular the condenser/gas cooler, the sub-cooler, the circuit-internal heat exchanger and the evaporator, as well as the collector for the refrigerant are advantageously thermally insulated from one another within the heat exchanger unit. At least one respective thermal insulation plate is arranged between the individual sections of the heat exchanger unit.

[36] According to a further development of the invention, the high-temperature coolant circuit has at least one first coolant heat exchanger connected via connecting lines to the first coolant unit and the first conveying device. The first coolant heat exchanger can be formed for heating components of the drive train of the motor vehicle or as a coolant-air heat exchanger for heating the supply air of the passenger compartment or for transferring heat to the ambient air.

[37] According to an advantageous design of the invention, the low-temperature coolant circuit has at least one second coolant heat exchanger connected via connecting lines to the second coolant unit and the second conveying device. The second coolant heat exchanger can be formed for cooling components of the drive train of the motor vehicle or as a coolant-air heat exchanger for cooling and/or dehumidifying the supply air of the passenger compartment or for transferring heat from the ambient air.

[38] The object is also achieved by methods according to the invention for operating a heat management system for a motor vehicle.

[39] A method according to the concept for operating the heat management system has the following steps when operating in a refrigeration system mode for conditioning the supply air of the passenger compartment, in particular for cooling and/or dehumidifying the supply air of the passenger compartment:

[40] - dividing a coolant circulating in a high-temperature coolant circuit into a first coolant partial mass flow and a second coolant partial mass flow,

[41] - conducting the first coolant partial mass flow through a condenser/gas cooler and the second coolant partial mass flow through a sub-cooler, wherein the coolant partial mass flows flow through the condenser/gas cooler and the sub-cooler in parallel and in the same direction,

[42] - mixing the coolant partial mass flows after flowing through the condenser/gas cooler and the sub-cooler and conducting the coolant through a switching means to a first coolant unit from which the coolant is drawn in by the first conveying device, and

[43] - conducting a refrigerant circulating in the refrigerant circuit at a high pressure level through the condenser/gas cooler in a counter-current to the first refrigerant partial mass flow, wherein the refrigerant is heated and condensed, and

[44] - conducting the refrigerant flowing out of the condenser/gas cooler through the sub-cooler in a co-current to the second coolant partial mass flow, wherein the refrigerant is sub-cooled or cooled down further.

[45] According to a further development of the invention, the coolant is passed from a conveying device through a valve arrangement formed as a switching means to a first coolant connection of a heat exchanger unit, which is operated as an inlet, before being divided into coolant partial mass flows, and is divided into the first coolant partial mass flow and the second coolant partial mass flow before flowing through the heat exchanger unit. In addition, after mixing the coolant partial mass flows, the coolant is conducted from a second coolant connection of the heat exchanger unit, which is operated as an outlet, through the valve arrangement to the coolant unit.

[46] According to an advantageous design of the invention, the valve arrangement is arranged in a first switching position such that the coolant is conducted from the first connection operated as an inlet and connected via a connecting line to the first conveying device to the third connection operated as an outlet and connected via a connecting line to the first coolant connection of the heat exchanger unit, and from the fourth connection operated as an inlet and connected via a connecting line to the second coolant connection of the heat exchanger unit to the second connection operated as an outlet and connected via a connecting line to the first coolant unit.

[47] A method according to the concept for operating the heat management system has the following steps when operating in a heating mode for conditioning the supply air of a passenger compartment, in particular for heating the supply air of the passenger compartment:

[48] - dividing a coolant circulating in a high-temperature coolant circuit into a first coolant partial mass flow and a second coolant partial mass flow,

[49] - conducting the first coolant partial mass flow through a condenser/gas cooler and the second coolant partial mass flow through a sub-cooler, wherein the coolant partial mass flows flow through the condenser/gas cooler and the sub-cooler in parallel and in the same direction,

[50] - mixing the coolant partial mass flows after flowing through the condenser/gas cooler and the sub-cooler and conducting the coolant through a switching means to a first coolant unit from which the coolant is drawn in by the first conveying device, and

[51] - conducting a refrigerant circulating in the refrigerant circuit at a high pressure level through the condenser/gas cooler in a co-current to the first refrigerant partial mass flow, wherein the refrigerant is heated and condensed, and

[52] - conducting the refrigerant flowing out of the condenser/gas cooler through the sub-cooler in a counter-current to the second coolant partial mass flow, wherein the refrigerant is sub-cooled or cooled down further.

[53] A further advantage of the invention is that the coolant is passed from a conveying device through a valve arrangement formed as a switching means to a second coolant connection of a heat exchanger unit, which is operated as an inlet, before being divided into coolant partial mass flows, and is divided into the first coolant partial mass flow and the second coolant partial mass flow before flowing through the heat exchanger unit. In addition, after mixing the coolant partial mass flows, the coolant is conducted from a first coolant connection of the heat exchanger unit, which is operated as an outlet, through the valve arrangement to the coolant unit.

[54] According to a preferred design of the invention, the valve arrangement is arranged in a second switching position such that the coolant is conducted from the first connection operated as an inlet and connected via a connecting line to the first conveying device to the fourth connection operated as an outlet and connected via a connecting line to the second coolant connection of the heat exchanger unit, and from the third connection operated as an inlet and connected via a connecting line to the first coolant connection of the heat exchanger unit to the second connection operated as an outlet and connected via a connecting line to the first coolant unit.

[55] By switching the flow direction of the coolant through the heat exchanger unit, in particular through the sub-cooler, between the operation of the heat management system in the refrigeration system mode and in the heating mode by means of the valve arrangement, the operation of the sub-cooler is changed from co-current between the refrigerant and the coolant to counter-current between the refrigerant and the coolant. By changing the flow direction of the coolant, in particular through the sub-cooler, a maximum heat transfer between the refrigerant and the coolant is achieved with temperature differences between the refrigerant and the coolant that can be adjusted in the case of different operating modes of the heat management system. With the reversible flow direction of the coolant, the good heat transfer between two liquid fluids in the coolant-cooled and thus liquid-cooled sub-cooler is adapted with predetermined installed hardware.

[56] Especially when operating the heat management system in the heating mode for conditioning the supply air of a passenger compartment and thus the counter-current of refrigerant and coolant within the sub-cooler, the heat transfer between the refrigerant and the coolant is maximised, so that, in addition, the sub-cooling of the refrigerant

at the outlet of the sub-cooler is increased in co-current in comparison with the application of fluids to the sub-cooler. The condensation temperature and the level of the high pressure of the refrigerant are thereby raised and thus the comfort in the passenger compartment is increased. Switching the flow direction of the coolant in the condenser/gas cooler has no other influence on the condensation process.

[57] The heat management system according to the invention also has a minimum number of components and low complexity and is thus easy to assemble. Components in the system are easy to replace. As a result of the integral construction of the components, the system also requires only a minimum installation space.

[58]

Brief Description of Drawings

[59] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[60] Fig. 1 shows a heat management system during operation in a refrigeration system mode.

[61] Fig. 2 shows a heat management system during operation in a heating mode.

Mode for the Invention

[62] Further details, features and advantages of the invention will become apparent from the following description of an exemplary embodiment with reference to the accompanying drawings.

[63] Figs. 1 and 2 each reveal a circuit diagram of a heat management system 1 with a refrigerant circuit 2, a high-temperature coolant circuit 6 and a low-temperature coolant circuit 11, which are thermally coupled to one another via refrigerant-coolant heat exchangers formed in a heat exchanger unit 4, during operation in a refrigeration system mode according to Fig. 1 and during operation in a heating mode according to Fig. 2. The operating modes are illustrated in each case through arrows by means of the flow directions on fluid-carrying connecting lines of the refrigerant circulating in the refrigerant circuit 2 and of the coolant circulating in the coolant circuits 6, 11. The arrows and connecting lines respectively marked with broken dashed lines show the refrigerant at a high pressure level - short dashed lines - and the refrigerant at a low pressure level - long dashed lines.

[64] The refrigerant circuit 2 has, in the flow direction of the refrigerant, a compressor 3 and the heat exchanger unit 4 with a condenser/gas cooler 4-1, a collector 4-2, a sub-cooler 4-3, a circuit-internal heat exchanger 4-4 and an evaporator 4-5. In addition, the refrigerant circuit 2 is formed with an expansion member 5 which is arranged between a high-pressure side of the circuit-internal heat exchanger 4-4 and the evaporator 4-5.

The refrigerant flowing out of the evaporator 4-5 is conducted to a low-pressure side of the circuit-internal heat exchanger 4-4. The refrigerant is sucked in by the compressor 3 from the low-pressure side of the circuit-internal heat exchanger 4-4. The refrigerant circuit 2 is closed.

[65] The high-temperature coolant circuit 6 of the heat management system 1 has a first coolant unit 7 with a coolant reservoir and optionally coolant valves, a first conveying device 8 and a valve arrangement 9. The valve arrangement 9 is formed as a 4/2-way valve with four connections 9-1, 9-2, 9-3, 9-4. A first connection 9-1 of the valve arrangement 9 is connected via a connecting line to the first conveying device 8 and always serves as an inlet of the valve arrangement 9, while a second connection 9-2 of the valve arrangement 9 is connected via a connecting line to the first coolant unit 7 and always serves as an outlet of the valve arrangement 9. A third connection 9-3 and a fourth connection 9-4 of the valve arrangement 9 are each connected via a connecting line to a coolant connection 4a, 4b of the heat exchanger unit 4 and are operated in accordance with a switching position of the valve arrangement 9 as an inlet or as an outlet for the coolant. To fulfil the same function, the valve arrangement can also be formed from several valves.

[66] Within the high-temperature coolant circuit 6, the condenser/gas cooler 4-1 and the sub-cooler 4-3 of the heat exchanger unit 4 of the refrigerant circuit 2 are arranged in such a way that the condenser/gas cooler 4-1 and the sub-cooler 4-3 can each be charged in parallel with coolant. First coolant connections 4a of the heat exchanger unit 4, in particular of the condenser/gas cooler 4-1 and of the sub-cooler 4-3, are connected via a connecting line to the third connection 9-3 of the valve arrangement 9, while in each case second coolant connections 4b of the heat exchanger unit 4, in particular of the condenser/gas cooler 4-1 and of the sub-cooler 4-3, are connected via a connecting line to the fourth connection 9-4 of the valve arrangement 9.

[67] The refrigerant-coolant heat exchangers operated as a condenser/gas cooler 4-1 or as a sub-cooler 4-3 of the refrigerant each enable a transfer of heat from the refrigerant circulating in the refrigerant circuit 2 to the refrigerant circulating in the high-temperature refrigerant circuit 6, in particular a water-glycol mixture.

[68] By means of the valve arrangement 9 formed as a 4/2-way valve, depending on the switching position, the first connection 9-1 serving as an inlet can be connected to the third connection 9-3 or the fourth connection 9-4, so that the third connection 9-3 or the fourth connection 9-4 are operated correspondingly as an outlet of the valve arrangement 9. In accordance with the switching position, the second connection 9-2 serving as an outlet is connected to the fourth connection 9-4 or the third connection 9-3, so that the fourth connection 9-4 or the third connection 9-3 are correspondingly operated as an inlet of the valve arrangement 9.

[69] The high-temperature coolant circuit 6 is also formed with at least one first coolant heat exchanger 10 which is connected via connecting lines to the first coolant unit 7 and the first conveying device 8. The first coolant heat exchanger 10 is operated as a heat sink for the coolant circulating in the high-temperature coolant circuit 6 and thus for the coolant circulating in the coolant circuit 2, and can be used for heating, for example, the supply air of the passenger compartment, components of the, in particular, electric drive train of the motor vehicle, or the transfer of heat to the ambient air.

[70] The low-temperature coolant circuit 11 of the heat management system 1 has a second coolant unit 12 with a coolant reservoir and, if appropriate, coolant valves and a second conveying device 13. In addition, the evaporator 4-5 of the heat exchanger unit 4 of the refrigerant circuit 2 is arranged within the low-temperature coolant circuit 11. A third coolant connection 4c of the heat exchanger unit 4 operated as an inlet of the evaporator 4-5 is connected to the second conveying device 13, while a fourth coolant connection 4d of the heat exchanger unit 4 operated as an outlet of the evaporator 4-5 is connected to the second coolant unit 12.

[71] The refrigerant-coolant heat exchanger, also referred to as a chiller, operated as an evaporator 4-5 of the refrigerant, makes it possible to transfer heat from the coolant circulating in the low-temperature coolant circuit 11, in particular a water-glycol mixture, to the refrigerant circulating in the refrigerant circuit 2.

[72] Furthermore, the low-temperature coolant circuit 11 is formed with at least one second coolant heat exchanger 14 which is connected via connecting lines to the second coolant unit 12 and the second conveying device 13. The second coolant heat exchanger 14 is operated as a heat source for the coolant circulating in the low-temperature coolant circuit 11 and thus for the refrigerant circulating in the refrigerant circuit 2 and can be used, for example, for cooling or dehumidifying the air to be supplied to the passenger compartment, components of the, in particular, electric drive train of the motor vehicle or for absorbing heat from the ambient air.

[73] The conveying devices 8, 13 of the coolant circuits 6, 11 are preferably in each case formed as a pump. The expansion member 5 of the refrigerant circuit 2 can be configured as an expansion valve.

[74] The heat exchanger unit 4 is formed as a plate heat exchanger consisting of individual heat exchanger plates. In particular, the condenser/gas cooler 4-1, the sub-cooler 4-3, the circuit-internal heat exchanger 4-4 and the evaporator 4-5 are combined from several plates each connected to form a plate pack. The condenser/gas cooler 4-1 and the sub-cooler 4-3 are each formed as a liquid-cooled, in particular coolant-cooled, heat exchanger. The individual heat exchangers and the collector 4-2 are each separated from one another, in particular by means of insulating plates, in order

to thermally insulate the heat exchanger regions operated at different temperature levels from one another. Alternatively, the heat exchanger unit 4 can also be formed combined as individual components of the condenser/gas cooler 4-1, of the sub-cooler 4-3, of the circuit-internal heat exchanger 4-4 and of the evaporator 4-5.

[75] Fig. 1 shows the heat management system 1 during operation in the refrigeration system mode.

[76] The refrigerant compressed to a high-pressure level when flowing through the compressor 3 flows through a refrigerant inlet of the heat exchanger unit 4 into the condenser/gas cooler 4-1 and is conducted in a counter-current to the coolant circulating in the high-temperature coolant circuit 6, which flows into the condenser/gas cooler 4-1 as a first coolant partial mass flow through the first coolant connection 4a of the refrigerant/coolant heat exchanger operated as an inlet. The refrigerant liquefied by heat transfer to the coolant circulating in the high-temperature coolant circuit 6 when flowing through the condenser/gas cooler 4-1 is then conducted to the collector 4-2, in which the liquid refrigerant is stored.

[77] The refrigerant then flows out of the collector 4-2 into the adjacently arranged sub-cooler 4-3, in which it is guided in a co-current to the coolant circulating in the high-temperature coolant circuit 6. The coolant is introduced into the sub-cooler 4-3 as a second coolant partial mass flow likewise through the first coolant connection 4a of the refrigerant-coolant heat exchanger operated as an inlet and thus parallel to the first coolant partial mass flow impinging on the condenser/gas cooler 4-1.

[78] The first and the second coolant partial mass flow of the high-temperature coolant circuit 6 can either be introduced into the heat exchanger unit 4 through a common first coolant connection 4a and divided within the heat exchanger unit 4 or can each flow into the heat exchanger unit 4 through a first coolant connection 4a.

[79] The first coolant partial mass flow flowing through the condenser/gas cooler 4-1 and the second coolant partial mass flow flowing through the sub-cooler 4-3 are heated and discharged from the heat exchanger unit 4 by the second coolant connection 4b operated as an outlet. The first and the second coolant partial mass flow can either be mixed with one another before flowing out of the heat exchanger unit 4 and can flow out of the heat exchanger unit 4 together through a second coolant connection 4b, or can flow out of the heat exchanger unit 4 through a second coolant connection 4b and then be mixed with one another.

[80] The liquid refrigerant, which is cooled when flowing through the sub-cooler 4-3 by dissipating heat to the coolant circulating in the high-temperature coolant circuit 6, is then introduced on the high-pressure side into the circuit-internal heat exchanger 4-4 in which it is passed in counter-current to the vaporous refrigerant flowing out of the evaporator 4-5 and introduced on the low-pressure side into the circuit-internal heat

exchanger 4-4. In this case, on the one hand, the liquid refrigerant is further cooled at the level of the high pressure after the sub-cooling, while on the other hand, the vaporous refrigerant is superheated at the level of the low pressure as the suction gas of the compressor 3.

[81] The liquid refrigerant cooled when flowing through the high-pressure side of the circuit-internal heat exchanger 4-4 is expanded to the level of the low pressure when flowing through the expansion member 5 and is then introduced into the evaporator 4-5.

[82] In the evaporator 4-5, the refrigerant is conducted in a counter-current to the coolant circulating in the low-temperature coolant circuit 11, which flows into the evaporator 4-5 through the third coolant connection 4c, operated as an inlet, of the refrigerant-coolant heat exchanger of the heat exchanger unit 4. The refrigerant evaporated when flowing through the evaporator 4-5 by absorbing heat from the coolant of the low-temperature coolant circuit 11 is then passed on the low-pressure side into the circuit-internal heat exchanger 4-4 in which the vaporous refrigerant is superheated. The superheated refrigerant is sucked off as suction gas by the compressor 3 from the circuit-internal heat exchanger 4-4.

[83] The cooled coolant circulating in the low-temperature coolant circuit 11 is discharged from the evaporator 4-5 of the heat exchanger unit 4 through the fourth coolant connection 4d operated as an outlet and guided to the second coolant unit 12. The coolant stored in the coolant reservoir of the second coolant unit 12 is conveyed by means of the second conveying device 13, on the one hand, through the third coolant connection 4c of the heat exchanger unit 4 into the evaporator 4-5 of the coolant and, on the other hand, through the at least one second coolant heat exchanger 14. When flowing through the second coolant heat exchanger 14, the coolant is heated by absorbing heat from the supply air of the passenger compartment or from components of the, in particular, electric drive train of the motor vehicle. In doing so, the supply air of the passenger compartment or the corresponding components of the drive train of the motor vehicle are cooled.

[84] The heated coolant circulating in the high-temperature coolant circuit 6 is discharged from the condenser/gas cooler 4-1 or the sub-cooler 4-3 of the heat exchanger unit 4 through the second coolant connection 4b operated as an outlet and is guided via the valve arrangement 9 to the first coolant unit 7. The fourth connection 9-4, which is operated as an inlet, and the second connection 9-2 of the valve arrangement 9 are connected to one another internally and are switched as a passage.

[85] The coolant stored in the coolant reservoir of the first coolant unit 7 is conveyed by means of the first conveying device 8, on the one hand, via the valve arrangement 9 to the first coolant connection 4a of the heat exchanger unit 4 and thus into the condenser/

gas cooler 4-1 or the sub-cooler 4-3 of the heat exchanger unit 4 and, on the other hand, through the at least one first coolant heat exchanger 10. The first connection 9-1 and the third connection 9-3 of the valve arrangement 9, which is operated as an outlet, are connected to one another internally and are switched as a passage.

[86] When flowing through the first coolant heat exchanger 10, the coolant is cooled by delivering heat to components of the, in particular, electric drive train of the motor vehicle or to the ambient air. In doing so, the corresponding components of the drive train of the motor vehicle can be heated.

[87] Fig. 2 shows the heat management system 1 during operation in the heating mode. The refrigerant circuit 2 and the low-temperature coolant circuit 11 are operated in the same way during operation of the heat management system 1 in the refrigeration system mode according to Fig. 1 and in the heating mode. The essential difference between the operating modes of the heat management system 1 in the heating mode and in the refrigeration system mode lies in the operation of the high-temperature coolant circuit 6, in particular in the switching position of the valve arrangement 9.

[88] Internally, the first connection 9-1 and the fourth connection 9-4, which is operated as an outlet, on the one hand, as well as the third connection 9-3, which is operated as an inlet, and the second connection 9-2 of the valve arrangement 9, on the other hand, are connected to one another and each switched as a passage.

[89] The refrigerant compressed to the high pressure level when flowing through the compressor 3 flows through the refrigerant inlet of the heat exchanger unit 4 into the condenser/gas cooler 4-1 and is conducted in a co-current to the coolant circulating in the high-temperature coolant circuit 6, which flows into the condenser/gas cooler 4-1 as a first coolant partial mass flow through the second coolant connection 4b of the refrigerant/coolant heat exchanger operated as an inlet. The refrigerant liquefied by heat transfer to the coolant circulating in the high-temperature coolant circuit 6 when flowing through the condenser/gas cooler 4-1 is then conducted to the collector 4-2.

[90] The refrigerant then flows out of the collector 4-2 into the adjacently arranged sub-cooler 4-3, in which it is guided in a counter-current to the coolant circulating in the high-temperature coolant circuit 6. The coolant is introduced into the sub-cooler 4-3 as a second coolant partial mass flow likewise through the second coolant connection 4b of the coolant-coolant heat exchanger, which is operated as an inlet, and thus parallel to the first coolant partial mass flow impinging on the condenser/gas cooler 4-1.

[91] The first and the second coolant partial mass flow of the high-temperature coolant circuit 6 can either be introduced into the heat exchanger unit 4 through a common second coolant connection 4b and divided within the heat exchanger unit 4 or can each flow into the heat exchanger unit 4 through a second coolant connection 4b.

[92] The first coolant partial mass flow flowing through the condenser/gas cooler 4-1 and the second coolant partial mass flow flowing through the sub-cooler 4-3 are heated and discharged from the heat exchanger unit 4 by the first coolant connection 4a operated as an outlet. The first and the second coolant partial mass flow can either be mixed with one another before flowing out of the heat exchanger unit 4 and can flow out of the heat exchanger unit 4 together through a first coolant connection 4a, or can flow out of the heat exchanger unit 4 through a first coolant connection 4a and then be mixed with one another.

[93] The heated coolant circulating in the high-temperature coolant circuit 6 is discharged from the condenser/gas cooler 4-1 or the sub-cooler 4-3 of the heat exchanger unit 4 through the first coolant connection 4a operated as an outlet and is guided via the valve arrangement 9 to the first coolant unit 7.

[94] The coolant stored in the coolant reservoir of the first coolant unit 7 is conveyed by means of the first conveying device 8, on the one hand, via the valve arrangement 9 to the second coolant connection 4b of the heat exchanger unit 4 and thus into the condenser/gas cooler 4-1 or the sub-cooler 4-3 of the heat exchanger unit 4 and, on the other hand, through the at least one first coolant heat exchanger 10.

[95] When flowing through the first coolant heat exchanger 10, the coolant is cooled by delivering heat to the supply air of the passenger compartment or to components of the in particular electric drive train of the motor vehicle, while the supply air of the passenger compartment is heated. Corresponding components of the drive train of the motor vehicle can also be heated.

[96] The coolant circulating in the low-temperature coolant circuit 11 is heated when flowing through the second coolant heat exchanger 14 by absorbing heat from components of the in particular electric drive train of the motor vehicle or from the ambient air. In doing so, the corresponding components of the drive train of the motor vehicle are cooled.

Industrial Applicability

[97] The invention relates to a heat management system for a motor vehicle with a refrigerant circuit and a high-temperature coolant circuit. The refrigerant circuit has a refrigerant-coolant heat exchanger operated as a condenser/gas cooler and a refrigerant-coolant heat exchanger operated as a sub-cooler, which are formed as components of the high-temperature coolant circuit, so that the refrigerant circuit and the high-temperature coolant circuit are thermally coupled to one another via the refrigerant-coolant heat exchangers.

[98] The invention also relates to a method for operating the heat management system for a motor vehicle for conditioning the supply air of a passenger compartment in a

refrigeration system mode, in particular for cooling and/or dehumidifying the supply air, and in a heating mode, in particular for heating the supply air of the passenger compartment.

Claims

[Claim 1] A heat management system (1) for a motor vehicle, having a refrigerant circuit (2) with a refrigerant-coolant heat exchanger operated as a condenser/gas cooler (4-1) and a refrigerant-coolant heat exchanger operated as a sub-cooler (4-3), and a high-temperature coolant circuit (6) with a coolant unit (7) and a conveying device (8), wherein the high-temperature coolant circuit (6) is formed such that the coolant circulating in the high-temperature coolant circuit (6) flows through the condenser/gas cooler (4-1) and the sub-cooler (4-3) as at least two coolant partial mass flows guided parallel to one another and in the same direction, wherein the flow directions of the refrigerant through the condenser/gas cooler (4-1) and the sub-cooler (4-3) are orientated opposite to one another, characterised in that the high-temperature coolant circuit (6) has a switching means for the flow direction of the coolant through the condenser/gas cooler (4-1) and the sub-cooler (4-3), which is configured such that the coolant in a first switching position of the switching means flows to the refrigerant through the condenser/gas cooler (4-1) in a counter-current and to the refrigerant through the sub-cooler (4-3) in a co-current and the coolant in a second switching position of the switching means flows through the condenser/gas cooler (4-1) to the refrigerant in a co-current and through the sub-cooler (4-3) to the refrigerant in a counter-current.

[Claim 2] The heat management system (1) according to claim 1, characterised in that the condenser/gas cooler (4-1) and the sub-cooler (4-3) are formed to be combined within a heat exchanger unit (4), wherein the heat exchanger unit (4) has at least one first coolant connection (4a) and at least one second coolant connection (4b) on which the condenser/gas cooler (4-1) and the sub-cooler (4-3) of the coolant circuit (2) are formed integrated into the high-temperature coolant circuit (6).

[Claim 3] The heat management system (1) according to claim 2, characterised in that the high-temperature coolant circuit (6) has a valve arrangement (9) as a switching means of the flow direction of the coolant, which is configured such that the coolant in the first switching position is conducted from the conveying device

(8) to the first coolant connection (4a) of the heat exchanger unit (4) operated as an inlet and from the second coolant connection (4b) of the heat exchanger unit (4) operated as an outlet to the coolant unit (7) and the coolant in the second switching position is conducted from the conveying device (8) to the second coolant connection of the heat exchanger unit (4) operated as an inlet and from the first coolant connection (4a) of the heat exchanger unit (4) operated as an outlet to the coolant unit (7).

[Claim 4] The heat management system (1) according to claim 3, characterised in that the valve arrangement (9) is formed as a 4/2-way valve with connections (9-1, 9-2, 9-3, 9-4) for integrating into the high-temperature coolant circuit (6), wherein a first connection (9-1) is formed connected as an inlet via a connecting line to the conveying device (8), a second connection (9-2) is formed connected as an outlet via a connecting line to the coolant unit (7), a third connection (9-3) is formed connected via a connecting line to the first coolant connection (4a) of the heat exchanger unit (4) and a fourth connection (9-4) is formed connected via a connecting line to the second coolant connection (4b) of the heat exchanger unit (4).

[Claim 5] The heat management system (1) according to claim 4, characterised in that the valve arrangement (9) is configured such that, in a first switching position, the first connection (9-1) is connected to the third connection (9-3) and the fourth connection (9-4) is connected to the second connection (9-2) and, in a second switching position, the first connection (9-1) is connected to the fourth connection (9-4) and the third connection (9-3) is connected to the second connection (9-2).

[Claim 6] The heat management system (1) according to any one of claims 2 to 5, characterised in that the condenser/gas cooler (4-1) and the sub-cooler (4-3) are formed as plate packs of a heat exchanger combined in a one-piece plate heat exchanger.

[Claim 7] The heat management system (1) according to any one of claims 2 to 6, characterised in that the refrigerant circuit (2) has a refrigerant-coolant heat exchanger operated as an evaporator (4-5).

[Claim 8] The heat management system (1) according to claim 7, characterised in that the evaporator (4-5) is formed integrated within the heat exchanger unit (4).

[Claim 9] The heat management system (1) according to claim 8, characterised in that the condenser/gas cooler (4-1), the sub-cooler (4-3) and the evaporator (4-5) are formed as plate packs combined in a one-piece plate heat exchanger.

[Claim 10] The heat management system (1) according to any one of claims 7 to 9, characterised in that a low-temperature coolant circuit (11), in particular with a coolant unit (12) and a conveying device (13), is formed, wherein the heat exchanger unit (4) has at least a third coolant connection (4c) and at least a fourth coolant connection (4d), on which the evaporator (4-5) of the refrigerant circuit (2) is formed integrated into the low-temperature coolant circuit (11).

[Claim 11] The heat management system (1) according to any one of claims 1 to 10, characterised in that the refrigerant circuit (2) has a collector (4-2) and a circuit-internal heat exchanger (4-4).

[Claim 12] The heat management system (1) according to claim 11, characterised in that the collector (4-2) and the circuit-internal heat exchanger (4-4) are formed integrated within the heat exchanger unit (4).

[Claim 13] The heat management system (1) according to claim 12, characterised in that the collector (4-2) and the circuit-internal heat exchanger (4-4) are formed as plate packs combined in a one-piece plate heat exchanger, wherein the collector (4-2) is arranged in the flow direction of the refrigerant between the condenser/gas cooler (4-1) and the sub-cooler (4-3) and the circuit-internal heat exchanger (4-4) is arranged in the flow direction of the refrigerant between the sub-cooler (4-3) and an evaporator (4-5).

[Claim 14] The heat management system (1) according to any one of claims 1 to 13, characterised in that the high-temperature coolant circuit (6) has at least one first coolant heat exchanger (10) which is connected via connecting lines to the coolant unit (7) and the conveying device (8) and is formed for heating components of a drive train of the motor vehicle or as a coolant-air heat exchanger for heating supply air of a passenger compartment or for transferring heat to ambient air.

[Claim 15] The heat management system (1) according to any one of claims 10 to 14, characterised in that the low-temperature coolant circuit (11) has at least one second coolant heat exchanger (14) which is connected via connecting lines to the coolant unit (12) and the conveying device (13) and is formed for cooling components of a drive train of the motor vehicle or as a coolant-air heat exchanger for cooling and/or dehumidifying supply air of a passenger compartment or for transferring heat from ambient air.

[Claim 16] A method for operating a heat management system (1) for a motor vehicle in a refrigeration system mode for conditioning the supply air of a passenger compartment, in particular for cooling and/or dehumidifying the supply air of the passenger compartment, having the following steps:
- dividing a coolant circulating in a high-temperature coolant circuit (6) into a first coolant partial mass flow and a second coolant partial mass flow,
- conducting the first coolant partial mass flow through a condenser/gas cooler (4-1) and the second coolant partial mass flow through a sub-cooler (4-3), wherein the coolant partial mass flows flow through the condenser/gas cooler (4-1) and the sub-cooler (4-3) in parallel and in the same direction,
- mixing the coolant partial mass flows after flowing through the condenser/gas cooler (4-1) and the sub-cooler (4-3) and conducting the coolant through a switching means to a coolant unit (7) from which the coolant is drawn in by a conveying device (8), and
- conducting a refrigerant circulating in a refrigerant circuit (2) through the condenser/gas cooler (4-1) in a counter-current to the first coolant partial mass flow, wherein the refrigerant is heated and condensed, and
- conducting the refrigerant flowing out of the condenser/gas cooler (4-1) through the sub-cooler (4-3) in a co-current to the second coolant partial mass flow, wherein the refrigerant is sub-cooled.

[Claim 17] The method according to claim 16 for operating the heat management system (1) for a motor vehicle according to any one of claims 3 to 15, characterised in that the coolant, before being divided into coolant partial mass flows, is conducted from a conveying device (8) through a valve arrangement (9) formed as a switching means to a first coolant connection (4a), operated as an inlet, of a heat exchanger unit (4) and, before flowing through the heat exchanger unit (4), is divided into the first coolant partial mass flow and the second coolant partial mass flow, and in that the coolant, after mixing the coolant partial mass flows, is conducted from a second coolant connection (4b), operated as an outlet, of the heat exchanger unit (4) through the valve arrangement (9) to a coolant unit (7).

[Claim 18] The method according to claim 17, characterised in that the valve arrangement (9) is arranged in a first switching position such that the coolant is conducted from a first connection (9-1) operated as an inlet and connected via a connecting line to the conveying device (8) to a third connection (9-3) operated as an outlet and connected via a connecting line to the first coolant connection (4a) of the heat exchanger unit (4), and from a fourth connection (9-4) operated as an inlet and connected via a connecting line to the second coolant connection (4b) of the heat exchanger unit (4) to a second connection (9-2) operated as an outlet and connected via a connecting line to a coolant unit (7).

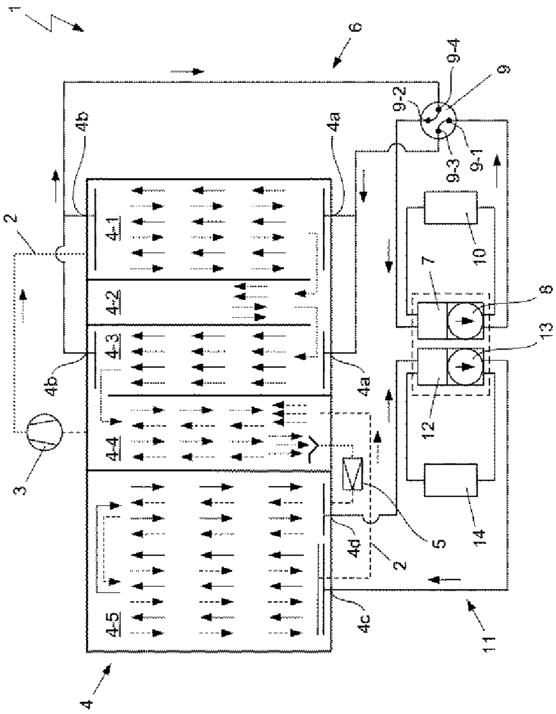
[Claim 19] A method for operating a heat management system (1) for a motor vehicle in a heating mode for conditioning the supply air of a passenger compartment, in particular for heating the supply air of the passenger compartment, having the following steps:
- dividing a coolant circulating in a high-temperature coolant circuit (6) into a first coolant partial mass flow and a second coolant partial mass flow,
- conducting the first coolant partial mass flow through a condenser/gas cooler (4-1) and the second coolant partial mass flow through a sub-cooler (4-3), wherein the coolant partial mass flows flow through the condenser/gas cooler (4-1) and the sub-cooler (4-3) in parallel and in the same direction,
- mixing the coolant partial mass flows after flowing through the condenser/gas cooler (4-1) and the sub-cooler (4-3) and conducting the coolant through a switching means to a coolant unit (7) from which the coolant is drawn in by the conveying device (8), and

- conducting a refrigerant circulating in a refrigerant circuit (2) through the condenser/gas cooler (4-1) in a co-current to the first coolant partial mass flow, wherein the refrigerant is heated and condensed, and
- conducting the refrigerant flowing out of the condenser/gas cooler (4-1) through the sub-cooler (4-3) in a counter-current to the second coolant partial mass flow, wherein the refrigerant is sub-cooled.

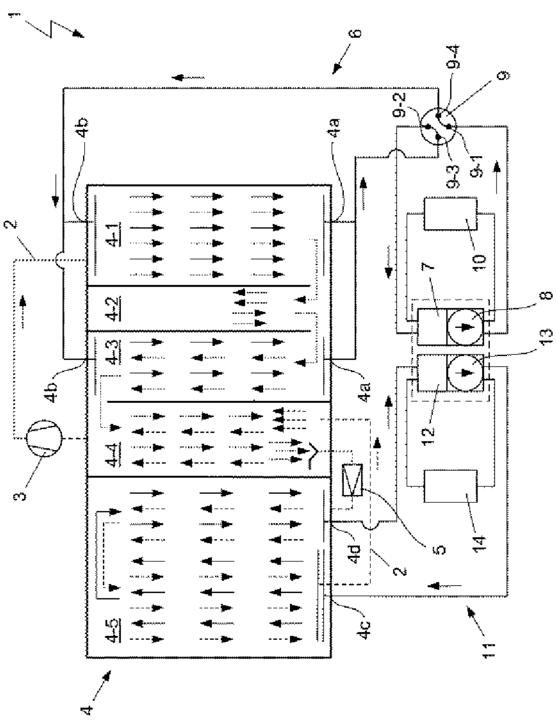
[Claim 20] The method according to claim 19 for operating the heat management system (1) for a motor vehicle according to any one of claims 3 to 15, characterised in that the coolant, before being divided into coolant partial mass flows, is conducted from a conveying device (8) through a valve arrangement (9) formed as a switching means to a second coolant connection (4b), operated as an inlet, of a heat exchanger unit (4) and, before flowing through the heat exchanger unit (4), is divided into the first coolant partial mass flow and the second coolant partial mass flow, and in that the coolant, after mixing the coolant partial flow mass, is conducted from a first coolant connection (4a), operated as an outlet, of the heat exchanger unit (4) through the valve arrangement (9) to a coolant unit (7).

[Claim 21] The method according to claim 20, characterised in that the valve arrangement (9) is arranged in a second switching position such that the coolant is conducted from a first connection (9-1) operated as an inlet and connected via a connecting line to the conveying device (8) to a fourth connection (9-4) operated as an outlet and connected via a connecting line to the second coolant connection (4b) of the heat exchanger unit (4), and from a third connection (9-3) operated as an inlet and connected via a connecting line to the first coolant connection (4a) of the heat exchanger unit (4) to a second connection (9-2) operated as an outlet and connected via a connecting line to a coolant unit (7).

[Fig. 1]


1
6
9-4
9
9-2
4b
4a
9-3
9-1
2
4-1
10
7
8
4-2
13
4-3
4b
4a
12
4-4
3
14
4-5
4d
2
5
4c
11
4

[Fig. 2]


1
6
9-4
9
9-2
4b
4a
9-3
9-1
2
4-1
10
7
8
4-2
13
4-3
4b
4a
12
4-4
3
14
4-5
4d
2
5
4c
11
4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/005573

A. CLASSIFICATION OF SUBJECT MATTER

B60H 1/32(2006.01)i; **B60H 1/00**(2006.01)i; **B60H 1/14**(2006.01)i; **F25B 40/00**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60H 1/32(2006.01); B60H 1/00(2006.01); F25B 29/00(2006.01); F25B 30/02(2006.01); F25B 39/04(2006.01); F28D 1/04(2006.01); F28D 9/00(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: vehicle, refrigerant-coolant heat exchanger, flow direction, opposite, valve

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2021-0178853 A1 (HANON SYSTEMS) 17 June 2021 (2021-06-17) paragraphs [0070], [0074]-[0078], [0082] and figures 3, 5	1-21
Y	KR 10-2021-0156999 A (HYUNDAI MOTOR COMPANY et al.) 28 December 2021 (2021-12-28) paragraphs [0039], [0083]-[0092] and figure 8	1-21
A	KR 10-1518356 B1 (DENSO CORPORATION) 08 May 2015 (2015-05-08) claims 1, 15 and figures 5-12	1-21
A	EP 2629040 B1 (MAHLE INTERNATIONAL G.M.B.H.) 29 July 2020 (2020-07-29) claims 1, 8 and figures 1-4	1-21
A	US 2015-0143835 A1 (SANDEN CORPORATION) 28 May 2015 (2015-05-28) claim 1 and figure 1	1-21

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 August 2024	**14 August 2024**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office **189 Cheongsa-ro, Seo-gu, Daejeon** **35208, Republic of Korea**	**PARK, Tae Wook**
Facsimile No. **+82-42-481-8578**	Telephone No. **+82-42-481-3405**

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2021-0178853 A1	17 June 2021	CN 112384393 A	19 February 2021
		DE 102018129988 A1	09 January 2020
		EP 3822101 A1	19 May 2021
		EP 3822101 B1	10 April 2024
		EP 4332490 A2	06 March 2024
		JP 2021-531197 A	18 November 2021
		JP 2024-057068 A	23 April 2024
		JP 7506654 B2	26 June 2024
		KR 10-2020-0006489 A	20 January 2020
		KR 10-2193569 B1	24 December 2020
		US 11613156 B2	28 March 2023
		US 2023-0103879 A1	06 April 2023
		WO 2020-013506 A1	16 January 2020
KR 10-2021-0156999 A	28 December 2021	None	
KR 10-1518356 B1	08 May 2015	CN 103459968 A	18 December 2013
		CN 103459968 B	09 December 2015
		EP 2696158 A1	12 February 2014
		EP 2696158 B1	29 September 2021
		JP 2012-225634 A	15 November 2012
		JP 2012-225638 A	15 November 2012
		JP 5772672 B2	02 September 2015
		KR 10-2014-0002774 A	08 January 2014
		US 2014-0245777 A1	04 September 2014
		WO 2012-137487 A1	11 October 2012
EP 2629040 B1	29 July 2020	CN 103245016 A	14 August 2013
		CN 103245016 B	05 September 2017
		CN 103370594 A	23 October 2013
		CN 103370594 B	30 March 2016
		CN 103375863 A	30 October 2013
		CN 103375863 B	31 May 2017
		CN 103380339 A	30 October 2013
		CN 103380339 B	20 January 2016
		CN 105143795 A	09 December 2015
		CN 105143795 B	24 May 2017
		CN 203190540 U	11 September 2013
		CN 203432005 U	12 February 2014
		EP 2629032 A2	21 August 2013
		EP 2629032 A3	08 June 2016
		EP 2629032 B1	12 July 2017
		EP 2629040 A2	21 August 2013
		EP 2629040 A3	11 April 2018
		EP 2676086 A1	25 December 2013
		EP 2676086 B1	18 December 2019
		EP 2676096 A1	25 December 2013
		EP 2676096 B1	23 October 2019
		EP 2972019 A1	20 January 2016
		EP 2972019 B1	30 May 2018
		US 2012-0210746 A1	23 August 2012
		US 2012-0216562 A1	30 August 2012
		US 2012-0222846 A1	06 September 2012

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
		US 2013-0283838 A1	31 October 2013
		US 2014-0190189 A1	10 July 2014
		US 2014-0284034 A1	25 September 2014
		US 2016-0298912 A9	13 October 2016
		US 8899062 B2	02 December 2014
		US 9109840 B2	18 August 2015
		US 9239193 B2	19 January 2016
		US 9494350 B2	15 November 2016
		US 9879891 B2	30 January 2018
		WO 2012-112634 A1	23 August 2012
		WO 2012-112760 A1	23 August 2012
		WO 2014-143621 A1	18 September 2014
US 2015-0143835 A1	28 May 2015	DE 112013001863 B4	18 July 2019
		DE 112013001863 T5	24 December 2014
		JP 2013-231573 A	14 November 2013
		JP 6216113 B2	18 October 2017
		US 9664423 B2	30 May 2017
		WO 2013-151008 A1	10 October 2013