(12) UK Patent (19) GB (11) 2623414 (13) B

(45) Date of B Publication **30.10.2024**

(54) Title of the Invention: Cooling system for an electric traction machine for a motor vehicle

(51) INT CL: ***B60K 11/02*** (2006.01) ***B60K 1/00*** (2006.01) ***H02K 9/19*** (2006.01)

(21) Application No: **2312586.7**

(22) Date of Filing: **17.08.2023**

(30) Priority Data:
(31) **102022125586** (32) **05.10.2022** (33) **DE**

(43) Date of A Publication **17.04.2024**

(56) Documents Cited:
WO 2021/195862 A1
CN 111959252 A
US 8080909 B2
CN 214564592 U
JP 2014007884 A

(58) Field of Search:
As for published application 2623414 A viz:
INT CL **B60K, B60L, H02K**
Other: **SEARCH-PATENT**
updated as appropriate

Additional Fields
INT CL **F16H**

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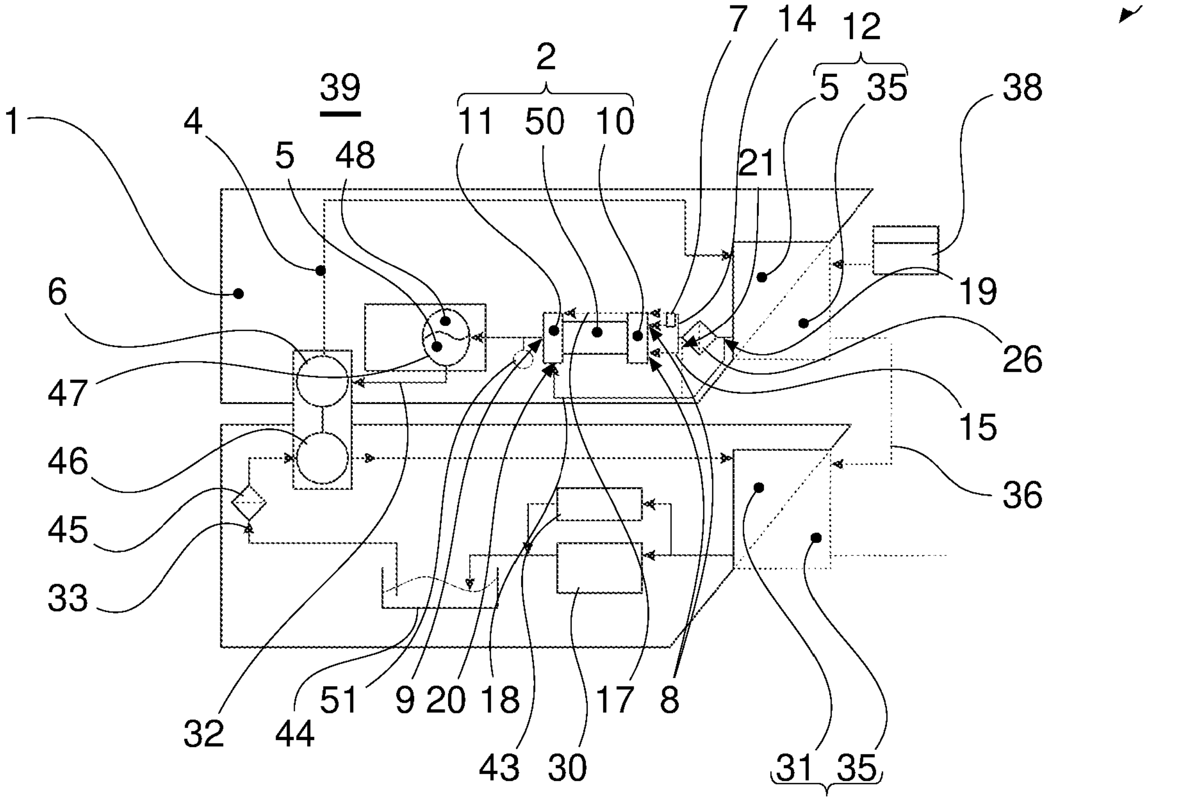
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Fig. 1

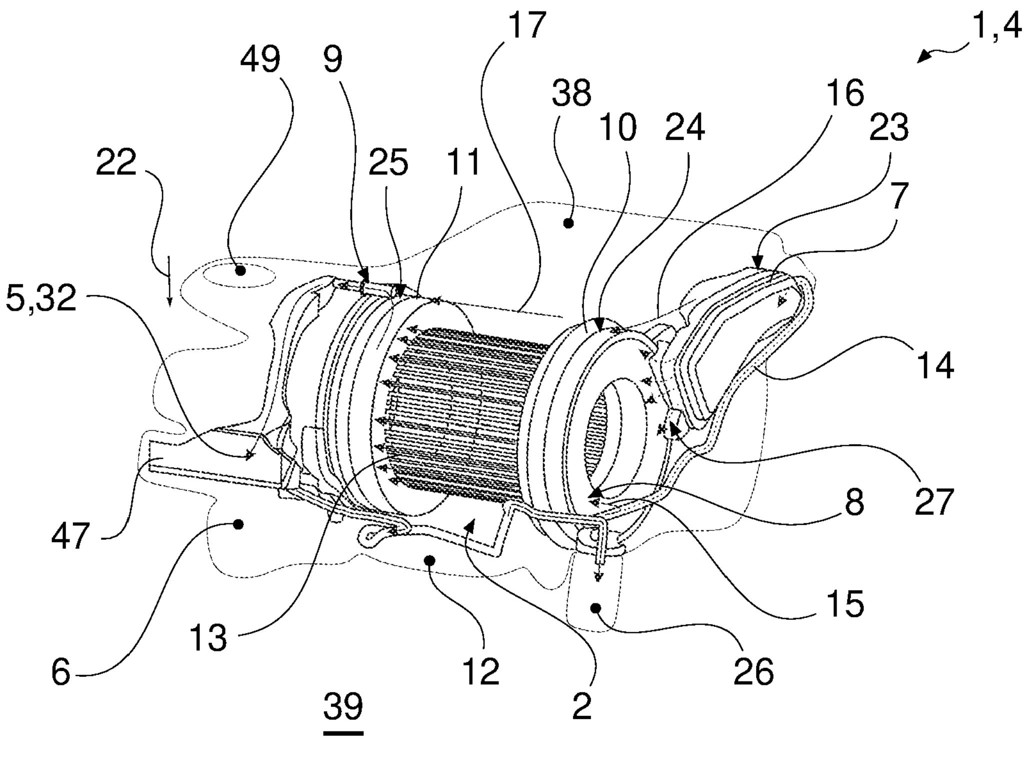
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Fig. 2

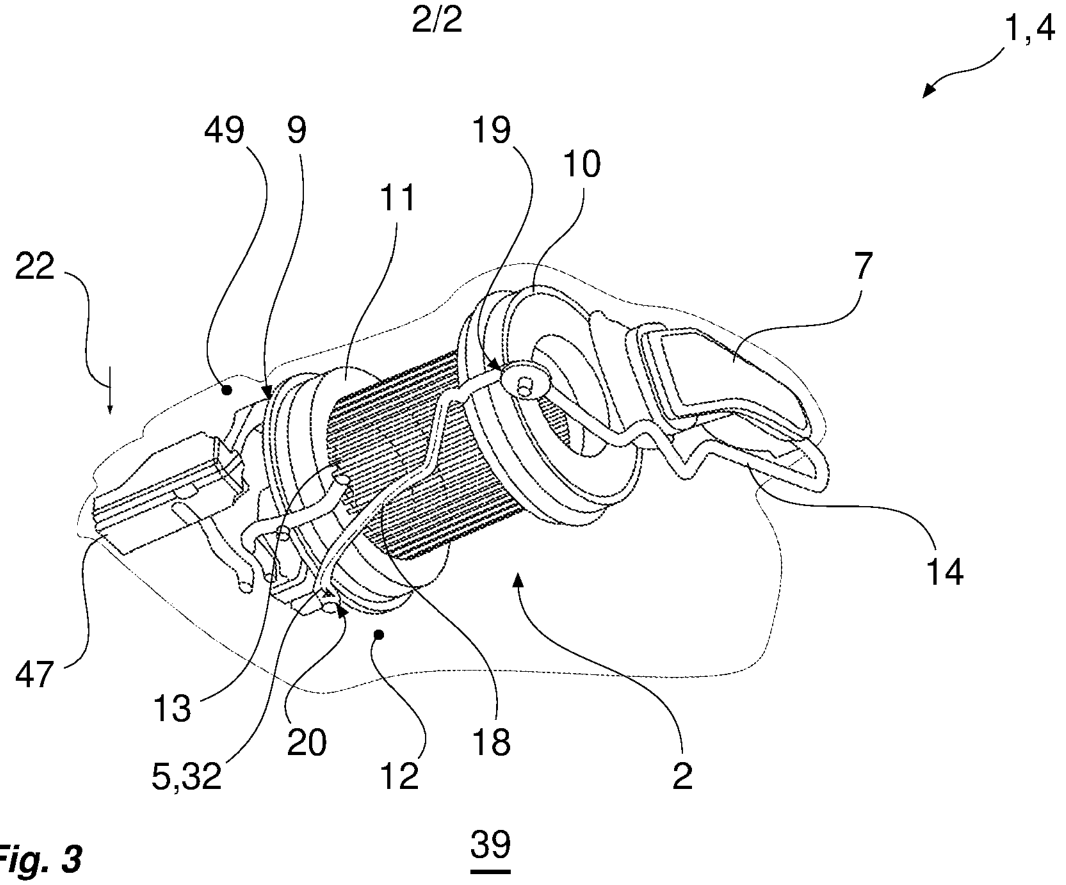
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Fig. 3

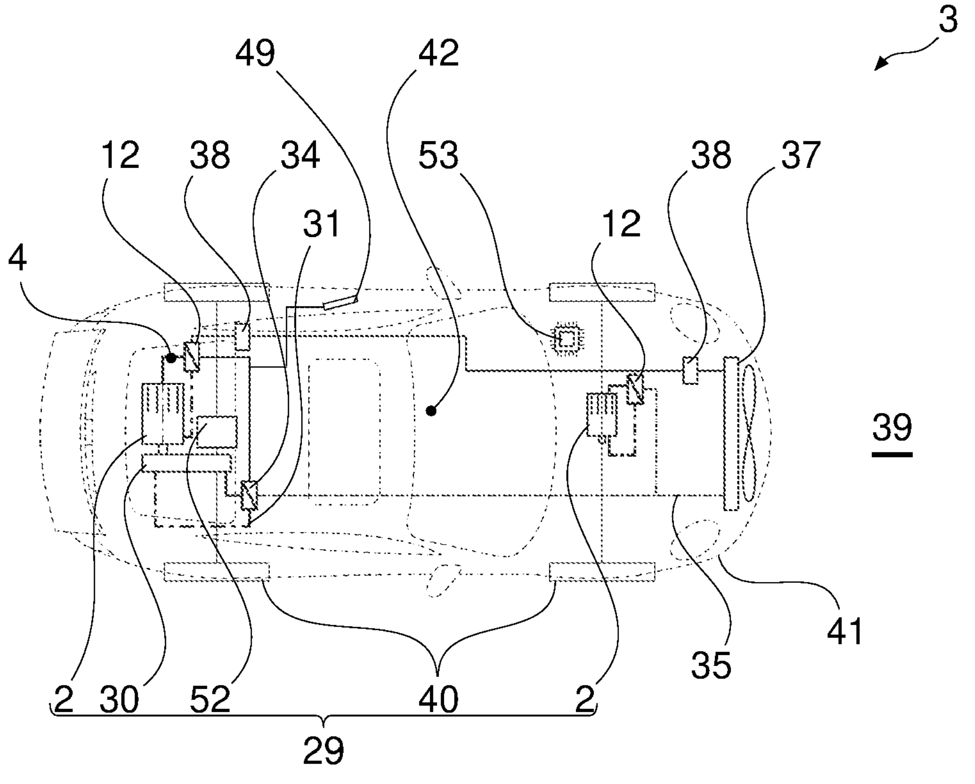
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Fig. 4

Cooling system for an electric traction machine for a motor vehicle

The invention relates to a cooling system for an electric traction machine for a motor vehicle, a thermal management module having such a cooling system for a powertrain of a motor vehicle, a powertrain having such a thermal management module for a motor vehicle, and a motor vehicle having such a powertrain.

From the prior art, cooling systems for electric traction machines are known for dissipating the resulting waste heat in case of a power demand. For increased cooling capacity, the idea is to directly perfuse at least the stator of an electric traction machine with a coolant, wherein the coolant is to be configured as a dielectric coolant. It is sensible to cool as few components as possible in this dielectric cooling system. Other components of a powertrain in which such an electric traction machine is integrated, such as a transmission and a pulse inverter, are preferably cooled in at least one separate cooling circuit. For example, a transmission is cooled by means of an oil circuit such that the coolant (transmission oil) is simultaneously set up so as to lubricate the transmission components. For example, a pulse inverter is arranged in a water circuit, with which further vehicle components are preferably coolable.

If a traction machine is cooled directly, as mentioned, it is necessary for the coolant (dielectric material) to be as good an electric insulator as possible. If there are air inclusions, this electrically insulating property and also the thermal capacity decreases. It is therefore desirable that, as far as possible, no air is found in the conduit system and, above all, does not remain there.

Starting therefrom, the problem addressed by the present invention is to at least partially overcome the disadvantages known from the prior art. The features according to aspects of the invention arise from the independent claims, and advantageous configurations thereof are disclosed in the dependent claims. The features of the claims can be combined in any technically meaningful manner, wherein the explanations from the following description as well as features from the figures, which comprise supplementary configurations of the invention, can also be used for this purpose.

A first aspect of the invention relates to a cooling system for an electric traction machine for a motor vehicle, comprising at least the following components:

- a circuit system for conducting a first coolant to be circulated;
- a first circulation pump for conveying the first coolant in the circuit system;
- an AC housing for an AC connection for the electric traction machine;

wherein the electric traction machine is to be temperature controlled and comprises an input side and an output side; the cooling system further comprising:

- a motor inlet connection for fluidly connecting the circuit system on the input side to an electric traction machine to be temperature-controlled;
- a motor outlet connection for fluidly connecting the circuit system on the output side to the electric traction machine to be temperature-controlled; and
- a first heat exchanger for dissipating heat from and/or supplying heat to the first coolant that is being circulated in the circuit system.

The cooling system is characterised in particular in that a first main line is provided, by means of which the first heat exchanger and the AC housing are fluidly connected to one another.

Reference will hereinafter be made to the specified respective direction of circulation or direction of conveyance, where in front of, behind and corresponding terms are used without explicit other indication. Ordinal numbers used in the description above and below are used only for clear differentiation and do not reflect any order or ranking of the designated components, unless explicitly indicated otherwise. An ordinal number greater than one does not necessitate that a further such component must necessarily be present.

In advance, it should be noted that, with the cooling system proposed here, waste heat must primarily be dissipated, but an increase in the temperature of components temperature-controlled by the cooling system is also a possible operating condition, for example in winter temperatures, so that the components are brought quickly to operating temperature. In most applications, however, waste heat is also to be dissipated in winter temperatures in the operation of an electric traction machine of a motor vehicle, i.e., cooling is the goal. It should also be noted that the cooling system proposed here is not limited to the use of a dielectric coolant, and is also operable, for example, by using temperature control with water and/or oil as the coolant. Then, an insulator, for example a casing, is preferably provided between the current-conducting components of the traction machine to be temperature-controlled and the (electrically conductive or not sufficiently electrically insulating) coolant.

It should further be noted that, for clarity in terms of components and properties to be described later, components or properties of the cooling system having the same name are respectively designated as first components or properties, wherein this is not always done in a clear context.

The cooling system comprises a circuit system which includes a plurality of lines and/or line sections between or in those components which can be temperature controlled by means of the cooling system. Within the circuit system, the first coolant is almost completely or partially encapsulated from an environment and therefore a loss of gaseous components occurs in negligible amounts at most (for example as a result of leaks) there. Nevertheless, gas (primarily air from the environment) enters through leaks, or gas pockets are present in the circuit system as a result of assembly or maintenance work.

A (first) circulation pump is provided for circulating the first coolant. A pressure gradient is generated by the circulation pump, resulting in a (first) circulation direction in the circuit system. In one embodiment, the circulation pump is operable for two circulation directions, but the first circulation direction is the main direction of operation, at least when dissipating waste heat from the integrated electric traction machine. A reversal of the direction is adjustable, for example, by reversing the direction of rotation of a pump wheel, but preferably by way of a corresponding way-valve.

In one embodiment, a compensation tank is provided and set up for equalizing the pressure between the circuit system and an environment, wherein gas inclusions in the first coolant can be separated here significantly as a result of a pressure drop (which may be e.g., open to the environment).

An electric traction machine is integrated into the cooling system for temperature control in that it is supplied with the first coolant via a motor inlet connection, wherein the first coolant introduced is discharged from the electric traction machine again via a motor outlet connection. The motor inlet connection is connected (preferably in the region of at least one of the two winding heads, i.e., the winding head region, for example enclosed by a housing) to the electric traction machine and the motor outlet connection is connected at the end that is axially opposite to the motor (with respect to the axis of rotation of the rotor shaft of the electric traction machine) (in the region of one, preferably others, of the two winding heads). It should be noted that when the (first) circulation direction is reversed, an outlet is formed from the motor inlet connection and an inlet is formed from the motor outlet connection. Preferably, however, the direction of flow via the electric traction machine remains the same; that is, the motor inlet connection is an inlet and the motor outlet connection is an outlet for the first coolant, wherein this is achieved, for example, by means of appropriate line routing and/or at least one switchable directional control valve.

The (first) heat exchanger is configured so as to transfer heat between two fluids, i.e., the first coolant and a further fluid (for example water or ambient air). In one embodiment for air cooling, for example, a fan is included.

An AC housing is furthermore provided in order to supply the electric traction machine, which houses an AC connection. By means of the AC connection, the traction machine (preferably controlled via external power electronics, for example comprising or formed by a pulse AC converter) is supplied with a power current or a power voltage. Here as well, there is a narrow optimal range for an operating temperature, so that it is desirable to temperature-control the AC housing or the AC connection that is located in it. Here, it is proposed to perform the temperature control using the cooling system, i.e., the first coolant that is used to temper the traction machine. For this purpose, a first main line is provided, which is fluidly connected by means of its (first) inlet (directly or indirectly) to the first heat exchanger and by means of its outlet (directly or indirectly) to the AC housing, wherein the inlet and outlet in each case are separate connection elements, or being formed by the respective component (for example in one piece).

In one advantageous embodiment, the first coolant is a dielectric coolant for direct contact with the electrically conductive and peripheral components (for example, AC power buses) of the traction machine to be temperature-controlled. A direct cooling is therefore a flow that directly contacts components of a unit to be temperature-controlled; for example, as a substitute for a lubricant or, as here in a traction machine, preferably (among other things) as a substitute for the insulation material between the stator winding and the stator lamination pack.

It is further proposed, in an advantageous embodiment of the cooling system, that the first main line is connected to the AC housing at the highest point in a normal orientation of the AC housing in the earth gravity field,
wherein preferably the highest point of the AC housing in the normal orientation is the same as or higher than at least one of the following components:

- the motor inlet connection;
- the motor outlet connection; and
- a different line section of the circuit system.

In one application of the cooling system in a thermal management module, there is a fixed alignment in the earth gravity field for assembly reasons. In a dynamic application, for example in an automotive vehicle, deviations from this fixed orientation are possible in operation, or there is a regular angular range in which a point forms the highest point, but also a different angular range (for example, when accelerating or decelerating), in which other points form the highest point in the earth gravity field. The deviating angular range occurs preferably sufficiently rarely and/or for a sufficiently short time. When a “highest point” is hereinafter referred to, this means a point by which the highest point of the respective component is formed in an application at least while idling, preferably also in a regular angular range. It should also be noted that the respective highest point in an application may not be the absolute highest point of a component, but rather a locally highest point (i.e., a local and not global maximum of the height) and/or that a technical deviation is also permitted with a highest point, for example, having a real highest point due to a manufacturing tolerance and/or due to a limited manufacturability, wherein the remaining volume (for tolerance-related or manufacturing-related reasons) is preferably negligible for the technical application.

It is now proposed that the first main line (preferably directly by means of its output) is connected to the AC housing at the highest point of the AC housing. In one embodiment, the first main line is connected to the AC housing just below this highest point, for example less than 2 cm [two centimetres], preferably less than 5 mm [five millimetres]). In one embodiment, the first main line is directly connected to the highest point of the AC housing. In a preferred embodiment, the output of the first main line is also the highest point of the first main line.

In one advantageous embodiment, the highest point of the AC housing is equal to or higher than the motor inlet connection, the motor outlet connection, and/or another line section of the circuit system (preferably only by a little, for example less than 1 cm [one centimetre], preferably no more than 2 mm [two millimetres]). Thus, an air inclusion with the cooling liquid can be carried along when circulating in (at least the first) circulation direction and thus can easily be discharged from the AC housing, i.e., in normal operation (preferably with a low or average operating pressure gradient).

Preferably, with a normal alignment of the AC housing (and the entire cooling system) between the highest (first) point of the AC housing, the highest (second) point of the first winding head region, and the highest (third) point of the second winding head region, there is no height difference, or a negligible height difference, or a lower height difference (as indicated above, for example). Thus, an air inclusion with the cooling liquid can be carried along when circulating in the (first) circulation direction and thus easily (preferably from the entire cooling system) out of the aforementioned components, i.e., in normal operation (preferably with a low or average operating pressure gradient), conveyed without undercuts up to an (optional) compensation tank, and there, such a gas can be discharged. Particularly preferably, in the normal orientation, no line section of the cooling system is provided which has a higher point than the specified points, wherein, preferably even until an (optional) expansion container has been reached, a respective highest line section is arranged not lower than, negligibly not as low as, or not as low as the specified points at the same time.

In an advantageous embodiment of the cooling system, it is furthermore proposed that the first main line be arranged upstream of a filter arranged behind the first heat exchanger.

Here, it is proposed that, by means of a filter, the AC housing or an AC connection arranged therein is protected against particles and/or large gas bubbles by retaining these in the filter or reducing them in size. In one application, it is possible that metallic particles are conveyed in the cooling system or its circuit system by a machined component or as a result of careless assembly. These are electrical conductors and can also mechanically damage the components (for example, abrasively or in an impacting manner) or in large quantities can also lead to clogging of thin line sections. By means of the filter, this is largely prevented. Alternatively or additionally, such a filter is not provided or is arranged downstream of the AC housing.

It is further proposed in an advantageous embodiment of the cooling system that a first vent line is provided between the AC housing and one, preferably the first, of the winding head regions of the electric traction machine to be temperature-controlled, wherein the first vent line is preferably indirectly or directly fluidly connected to at least one of the following highest points in the earth gravity field in a normal orientation of the cooling system:

- with the highest point of the AC housing;
- with the highest point of a first winding head region of the electric traction machine to be temperature-controlled; and
- with the highest point of a second winding head region of the electric traction machine to be temperature-controlled.

At the heat exchanger, a (first) input is provided and at the AC housing an output is provided, wherein the input and output are separate connection elements or are formed by the component in question (for example, integrally).

By means of the (first) vent line, gas enclosed in the AC housing is easily conveyable by means of the (first) cooling liquid to one of the winding head regions, preferably the first winding head region for reasons of relative spatial arrangement. Here, too, the gradient or the increase (in the first circulation direction) of the first vent line is preferably low, i.e., between the AC housing and the respective winding head region, preferably both winding head regions, as well as a second vent line, for example, as described below.

As already described above, a height difference between the highest points is preferably low. Independently thereof, a separate line section for discharging gas inclusions is preferably provided by means of the first vent line, which also fluidly connects the respective highest points of the AC housing and the first winding head region and/or (if necessary indirectly via a further, for example the aforementioned second, vent line) the second winding head region. In this respect, the aforementioned low height differences are preferably present, or else none are present.

It is further proposed in an advantageous embodiment of the cooling system that a second vent line is provided, by means of which, in a normal orientation of the electrical traction machine in the earth gravity field, the respective highest points of winding head regions of the electrical traction machine to be temperature-controlled are fluidly connected to one another.

For example, two highest points are equal in height or different in height (preferably only by a little, for example less than 1 cm [one centimetre], preferably not more than 2 mm [two millimetres]). Thus, an air inclusion with the cooling liquid can be carried along when circulating in (at least the first) circulation direction and thus can easily be discharged from the respective component, i.e., in normal operation (preferably with a low or average operating pressure gradient).

It is now proposed that a second vent line is provided. It should be noted that the description as a second vent line does not necessarily mean that a first vent line is provided.

The (second) vent line is arranged so that the winding head regions are fluidly connected to one another at their respective highest points, i.e., a gas or a gas bubble is carried along from one of the winding head regions to the other winding head region with the cooling liquid in the (respectively given) circulation direction, and preferably conveyed to a compensation tank and deposited therein. Preferably, this second vent line is provided separately from passages for temperature-controlling the electrical traction machine, so that a maximum temperature-controlling power, a low counter-pressure, and a good electrical insulation is ensured there, because gas inclusions are likely to be guided exclusively via the second vent line.

According to a further aspect, a thermal management module for a powertrain of a motor vehicle is proposed, comprising at least the following components:

- for a transmission, an oil circuit having a second circulation direction and having a second heat exchanger;
- for at least one vehicle component, a water circuit having a third circulation direction and having a third heat exchanger; and
- for an electric traction machine, a cooling system according to one embodiment according to the above description,

wherein, preferably, a pulse inverter for the electric traction machine is arranged in the water circuit.

Here, the cooling system described above is integrated into a thermal management module for a powertrain of a motor vehicle, wherein this thermal management module [TMM] is well known for its functions and tasks. In addition to components of a powertrain, other vehicle components are preferably also temperature-controlled, for example a (preferably traction) battery.

Other components of a powertrain in which such an electric traction machine is integrated, such as a transmission and a pulse inverter, are preferably cooled in at least one cooling circuit that is separate from the cooling system. For example, a transmission comprising a (preferably switchable) gearbox and/or a differential is cooled by way of an oil circuit with an oil, preferably directly. A direct cooling is a flow that directly contacts components of the transmission (for example gears), for example as a substitute for a lubricant. For example, the oil circuit is conventional. In one advantageous embodiment, a second circulation pump for generating a second circulation direction in the oil circuit is coupled to the first circulation pump for generating the first circulation direction in the circuit system for the first coolant as a so-called tandem pump, such that a single drive is sufficient for both circulation pumps. The waste heat is thereby released via the second heat exchanger.

Vehicle components to be temperature-controlled, which are not arranged in the oil circuit or the cooling system, are preferably temperature-controlled by means of a water circuit. The water is often a water-glycol mixture. The water of the water circuit is conveyed (by means of a third circulation pump) in a third circulation direction via a third heat exchanger. The third heat exchanger is preferably configured for heat transfer with the environment or the ambient air, wherein a fan is preferably provided for a (forced) convection on the third heat exchanger.

It should be noted that the respective components are also heatable in the oil circuit and/or the water circuit, for example in winter temperatures, wherein, however, the main state here is also the dissipation of waste heat. The respective circulation direction is also reversible, where appropriate.

In one advantageous embodiment, a pulse inverter [PWR] for an electric traction machine to be temperature-controlled by the cooling system with the first coolant is arranged in the water circuit for temperature control, i.e., not a component to be temperature-controlled in the cooling system with the first coolant. It is advantageous to keep the number of components in said cooling system for an electric traction machine low. With a pulse inverter, the use of a dielectric (first) coolant is not necessary. It is therefore advantageous to arrange the pulse inverter outside of said cooling system.

It is further proposed in an advantageous embodiment of the thermal management module that the water circuit is connected to the first heat exchanger of the cooling system for an electric traction machine for heat transfer, preferably as the only liquid-bound heat transfer means of the cooling system to the environment,
wherein, preferably in the third circulation direction of the water circuit, a pulse inverter for an electric traction machine is arranged upstream of the first heat exchanger.

It is proposed here that the cooling system be heat-coupled to the first coolant and the water circuit, i.e., the water circuit is configured by means of the (first) heat exchanger for temperature control of the first coolant. Thus, in the first heat exchanger, for example upon cooling of the electric traction machine (technically without liquid exchange), the heat is released from the first coolant to the water in the water circuit.

In a preferred embodiment, no further (forced) convection is provided for temperature control of the electric traction machine (and preferably also not further components in the cooling system) and for dissipating heat from the first coolant. Rather, the first heat exchanger is then the only unit of the cooling system for transferring heat, namely with the water circuit.

In a preferred embodiment, the pulse inverter is arranged in the (third) circulation direction of the water circuit upstream of the first heat exchanger so that the temperature gradient above the pulse inverter is as large as possible, while the temperature gradient above the first heat exchanger (due to the mostly very large heat output of the electric traction machine) is still sufficient.

In one advantageous embodiment, a reversing valve is provided for reversing the (first) circulation direction. In one embodiment, the first coolant then passes through a separate return channel. Preferably, the same conduit is used for both directions.

Thus, in the main direction, the order of the components is (beginning with the first circulation pump):

1. the first circulation pump;
2. the first heat exchanger;
3. the electric traction machine; and
4. the compensation tank.

In this case, within the main direction, the bypass section according to the above description is preferably arranged in such a manner that it connects a line section of the circuit system from the first circulating pump to a line section upstream of the compensation tank. And, in the secondary direction, the order of the components is:

1'. the first circulation pump;
2'. the compensation tank;
3'. the first heat exchanger; and
4'. the electric traction machine.

It should be noted that flow also passes through possible further components in the cooling system in reverse order, or flows through only some or exclusively the mentioned three components in reverse order.

It is furthermore proposed in an advantageous embodiment of the thermal management module that the water circuit is also connected to the second heat

exchanger of the oil circuit for heat transfer, preferably as the only liquid-borne heat transfer of the cooling system to the environment,
wherein, preferably in the third circulation direction of the water circuit, the first heat exchanger is arranged upstream of the second heat exchanger.

It is proposed here that the oil circuit and the water circuit be heat-coupled to one another, i.e., the water circuit is configured by means of the (second) heat exchanger for temperature control of the oil. In the second heat exchanger, for example, when the transmission cools (technically without liquid exchange), the heat from the oil in the oil circulation is released to the water in the water circuit.

In a preferred embodiment, no further (forced) convection is provided for temperature control of the transmission (and preferably also not for further components in the oil circuit) and for dissipating heat from the oil. Rather, the second heat exchanger is then the only unit of the oil circuit for heat transfer, namely with the water circuit.

In a preferred embodiment, the first heat exchanger is arranged in the (third) circulation direction of the water circuit upstream of the second heat exchanger so that the temperature gradient above the first heat exchanger is as large as possible, while the temperature gradient above the second heat exchanger (due to the mostly higher permissible temperature level in a transmission in comparison to an electric traction machine) is still sufficient.

According to a further aspect, a powertrain for a motor vehicle is proposed, comprising at least the following components:

- at least one electric traction machine to provide a torque;
- at least one propulsion wheel for propelling the relevant motor vehicle by means of a torque of the electric traction machine;
- at least one transmission for conducting a torque between the electric traction machine and at least one of the propulsion wheels; and
- a cooling system according to one embodiment as per the above description for at least one of the electric traction machines and/or a thermal management module according to one embodiment according to the above description for at least one of the electric traction machines, at least one of the transmissions and at least one vehicle

component, and preferably a pulse inverter for at least one of the electric traction machines.

A powertrain is now proposed here, which comprises at least one electric traction machine by means of which torque is generated. The torque of the respective electric traction machine is transferable via a transmission to at least one propulsion wheel. The at least one propulsion wheel is configured so as to drive the motor vehicle forward. The temperature control of the components of the powertrain is performed by a cooling system or a thermal management module comprising a cooling system according to one embodiment according to the above description. For the third heat exchanger, the air of the environment is preferably used, namely passively by means of driving wind and/or actively by means of a fan.

In a further aspect, a motor vehicle is proposed, comprising a chassis having a transport compartment and a powertrain according to an embodiment according to the description above for driving the automotive vehicle forward.

The motor vehicle is provided for transporting at least one passenger and/or goods and comprises a passenger compartment and/or a cargo compartment. The motor vehicle is driven via the at least one propulsion wheel by means of the torque of at least one of the electric traction machines.

The invention described above is explained in detail below with reference to the accompanying drawings, which show preferred configurations, in light of the relevant technical background. The invention is not limited in any way by the purely schematic drawings, wherein it is noted that the drawings are not true to size and are not suitable for defining proportions. The figures show:

Fig. 1 a thermal management module in a schematic diagram;

Fig. 2 a cooling system in a first spatial view;

Fig. 3 the cooling system according to Fig. 2 in a second spatial view; and

Fig. 4 a motor vehicle having a thermal management module in a schematic top view.

Fig. 1 shows a thermal management module **28** in a schematic diagram, comprising a cooling system **1** according to Fig. 2 for an electric traction machine **2**. A first heat exchanger **12** of the cooling system **1** is set up here for heat transfer with a water circuit **35** (only shown in a section here), so that the first coolant **5** of the circuit system **4** of the cooling system **1** and the water (mixture) of the water circuit **35** are in the heat exchange with one another. A second heat exchanger **34** of an oil circuit **31** for a transmission **30** is also configured here for heat transfer with the water circuit **35** (shown only in a section here), so that the oil of the oil circuit **31** and the water (mixture) of the water circuit **35** are in the heat exchange with one another.

In the water circuit **35**, a pulse inverter **38** for the electric traction machine **2** to be temperature-controlled in the cooling system **1** is arranged here, namely in the (third) circulation direction **36** of the water circuit **35** upstream of the first heat exchanger **12** of the cooling system **1** with the (first) coolant **5**. In addition, the second heat exchanger **34** is arranged behind the first heat exchanger **12** in the third circulation direction **36**.

In the oil circuit **31**, in the (second) circulation direction **33**, a transmission **30** and a transmission component **43** are arranged behind the second heat exchanger **34**, which are connected here in parallel to one another. Subsequently, an oil sump **44**, consequently a coarse filter **45** and finally (shown in the illustration) a second circulation pump **46**, are arranged in the oil circuit **31**. The second circulation pump **46** is here (purely optionally) embodied as a tandem pump with a first circulation pump **6** of the cooling system **1** having the first coolant **5**.

The cooling system **1** comprises a circuit system **4**in which the following components are arranged in the (first) circulation direction **32**:

1. the first circulation pump **6**;
2. the first heat exchanger **12**;
3. a purely optional (oil) filter **26**;
4. the electric traction machine **2**, which is perfused via a motor inlet connection **8** and a motor outlet connection **9**; and
5. a compensation tank **47**.

The compensation tank **47** is filled partially with the first coolant **5** and partially with a gas **48**, so that a pressure increase resulting from a temperature-related increase in volume can be compensated or at least reduced by means of the volume compensation tank **49** (not shown here) and the compressible gas **48** contained therein. Alternatively, the compensation tank **47** is configured for exchanging air from the environment **39**. This exchanged air can be completely or partially freed from components of the coolant, humidity or contamination with appropriate filters. It should be noted that, in the shown embodiment of the thermal management module **28**, no heat exchanger is provided from the cooling system **1** and the oil circuit **31** for heat transfer to the environment **39.** Rather, the first heat exchanger **12** and the second heat exchanger **34** are coupled to the water circuit **35**.

The electric traction machine **2** is here provided with (purely optional) vent lines **16,17** , main lines **14,15** and a bypass line **18.** The electric traction machine **2** is detailed here with a first winding head region **10** (shown at the right end) of a stator lamination pack **50** (preferably with cooling grooves **13** as shown in Fig. 2 and Fig. 3) and a second winding head region **11** (shown at the left end), wherein the designation as the first winding head region **10** and second winding head region **11** is selected solely according to the flow sequence in the first circulation direction **32**, without consideration of the bypass line **18.** Advantageous embodiments of the vent lines **16,17**, the main lines **14,15** and the bypass line **18** are shown and explained in more detail in the following Figs. 2 and 3. Purely optionally, a temperature sensor **51** for sensing the temperature of the first coolant **5** in the circuit system **4** of the cooling system **1** is provided behind the electric traction machine **2**.

Directly behind the first heat exchanger **12**, a bypass line **18** is branched off via a first connector **19**, which is fluidly connected directly via the second connector **20** to the second winding head region **11** of the electric traction machine **2**. Here, a purely optional third connection **21** is shown (dashed), which alternatively or additionally supplies the bypass line **18.**

Furthermore, a purely optional second vent line **17** is shown (dotted) between the two winding head areas **10,11**, which is formed separately from a flow through the stator lamination pack **50**. The second vent line **17** is preferably connected to the respective highest point, at least at the first winding head region **10** the highest (second) point **24** (see Fig. 2), wherein the second vent line **17** is preferably arranged in the normal orientation of an application of the thermo-management module **28** in the earth gravity field **22** without raising or lowering with an extent parallel to the earth gravity field **22**, i.e., preferably no hydraulic undercuts are formed.

A branching is provided in front of the first winding head region **10** (and purely optionally behind the (oil) filter **26**), wherein a (purely optional second) main line **15** is directly connected to the first winding head region **10**, and a (purely optional first) main line **14** is routed via an AC housing **7** and only thereafter into the first winding head region**10**. It should be noted that in one embodiment, only a first main line **14**, i.e., the traction machine **2** is supplied with (the first) coolant **5** solely via the AC housing **7**, and in an alternative embodiment, only a second main line **15** according to this designation is provided. In an embodiment with both a first main line **14** and a second main line **15**, the first main line **14** is preferably feedable at a higher flow rate than the second main line **15**, the (first) flow rate of the first main line **14** preferably being (about) twice as great or more than the (second) flow rate of the second main line **15.** In one embodiment, a ratio of the flow rates of the main lines **14,15** can be changed; for example, at least one of the main lines **14,15** can be closed, and/or the associated flow rate can be controlled.

Fig. 2 shows a cooling system **1** in a spatial view, wherein the components are shown transparently here (with a dotted line), and the liner of the circuit system **4** is shown with a solid line. Purely functionally, reference is made to the cooling system **1** in the circuit diagram according to Fig. 1, wherein only one possible embodiment of a cooling system **1** according to the circuit diagram described above is shown without exclusion of generalities.

The electric traction machine **2** can be seen at the centre or the housing, which comprises cooling for the first winding head region **10** (shown on the right) and for the second winding head region **11**, as well as a plurality of cooling grooves **13.**

Spatially behind the traction machine **2**, there are power electronics comprising at least one pulse inverter **38** and to the left of the traction machine **2**, a volume compensation tank **49** (purely optional) is indicated, wherein the volume compensation tank **49** (for the first coolant **5** as a dead end) being connected to the compensation tank **47**. The volume compensation tank **49** is adapted to compensate for volume fluctuations as a result of pressure variations and/or gas inclusions, and is arranged so that it is open or closed to the environment **39**.

On the left, a compensation tank **47** is shown as an L-shaped structure in an advantageous embodiment, which is directly connected to the motor outlet connection **9** at the second winding head region **11** and connected to the (first) heat exchanger **12** via a (first) circulation pump **6.** The heat exchanger **12**, in turn, is fluidly connected to the first winding head region **10** via a (purely optional) (oil) filter **26** and a second main line **15** which is connected thereafter.

Branching off from the second main line **15** (and thus behind the (oil) filter **26**), a first main line **14** can be seen, which is fluidly connected to the AC housing **7** at its (purely optionally highest) point **23**. It should be noted that this does not mean that the first main line **14** is subordinate to the second main line **15** or necessarily has a lower flow rate. Again, the AC housing **7** is fluidly connected to the first winding head region **10** via (here a plurality of) connecting lines **27.** However, a separate (first) vent line **16** is also provided here, which is fluidly connected to the highest (first) point **23** of the AC housing **7** and the highest (second) point **24** of the first winding head region **10**. As the name says, this is adapted to remove gas entrapments from the AC housing **7**. The coolant **5**, which is routed via the connecting lines **27**, is therefore highly likely to be gas-free or a co-distributed gas quantity is negligible.

A separate second vent line **17** is provided between the first winding head region **10** and the second winding head region **11** in parallel to the cooling grooves **13** by means of which the highest (second) point **24** of the first winding head region **10** and the highest (third) point **25** of the second winding head region **11** are fluidly connected to one another. Preferably, these highest points **23,24,25** are all arranged at the same level when the cooling system **1** is in a normal orientation in the earth gravity field **22**. Preferably, the cooling grooves **13** are in direct contact with the stator lamination pack **50** and/or the stator winding (both not shown here), for example by being provided as recesses, preferably directly in the grooves for a stator winding. In one embodiment, the cooling grooves **13** are formed in the intermediate space in the stator grooves and the winding; for example, embodied as so-called hair pins (and optionally insulation paper in the stator grooves).

In Fig. 3, the cooling system **1** according to Fig. 2 is shown in a second spatial view, wherein a bypass line **18** (only optionally provided) can be seen here. Apart from this, without exclusion of generalities, reference is made to Fig. 2 purely for clarity.

Via a first connection **19**, the bypass line **18** is branched out (exclusively here) in the recirculation direction **32** in front of the (oil) filter **26** and behind the first heat exchanger**12.** The bypass line **18** is fluidly connected to the second winding head region **11** via the second connector **20**. The remaining lines (i.e., the first main line**14**, the second main line**15** and the cooling grooves **13**) are thus bridged and an immediate connection between the heat exchanger **12** and the second winding head region**11** is created and the second winding head region**11** is thus supplied with the coolant**5** with a lower temperature in the event of cooling, as if the second winding head region**11** is exclusively downstream of the second winding head region**11** (and optionally the AC housing**7**) and the stator lamination pack **50** in the circulation direction**32**.

In Fig. 4, a motor vehicle **3** with a thermal management module **28** is shown in a schematic top plan view with a powertrain **29**. The motor vehicle **3** comprises a transport compartment **42**, for example a passenger compartment, approximately in the centre of its chassis **41**, and four propulsion wheels **40** to propel the motor vehicle **3** on and to the side of its chassis **41**. In front, there is an electric traction machine **2** (optionally purely coaxial here) and behind, there is a further electric traction machine **2** (in this case purely optionally axially arranged), as well as behind, there is a transmission **30** and a differential **52**, preferably wherein the differential **52** is integrated into the oil circuit **31** (not shown here). A pulse inverter **38** is provided for each of the front and rear electric traction machines **2**. A water circuit **35** is configured for the temperature control of the pulse inverter **38** and the first heat exchangers **12** and the second heat exchanger **34**, wherein the heat of the water circuit **35** can be dissipated to the environment **37** via a third heat exchanger **39** (shown here with a fan). The leading conduit is shown here with a solid line and the return line respectively as a dotted line so that the (third) circulation direction **36** of the water circuit **35** runs counterclockwise in the illustration. Likewise, this is shown in the cooling system**1** on the electric traction machines **2** and in the oil circuit **31**. For example, the cooling systems **1**, the oil circuit **31**, and the water circuit **35** are embodied as shown in Fig. 2 and 3 as well as Fig. 1 (at least sectionally). Furthermore, a processor **53** is indicated here by means of which the necessary control and/or control of the shown (and possibly further) components can be implemented. The processor **53** is configured as a CPU, for example, and/or is part of an on-board computer of the motor vehicle **3**. Here, purely optionally (for example in a carrier and/or rocker) a volume compensation tank **49** that is closed to the environment **39**, for example, is provided.

With the first main line proposed herein, an AC connector is incorporated into a cooling system for an electrical traction machine in a manner so as to be efficiently cooled.

List of reference numbers

1 Cooling system
2 Traction machine
3 Motor vehicle
4 Circuit system
5 First coolant
6 First circulation pump
7 AC housing
8 Motor inlet connection
9 Motor outlet connection
10 First winding head region
11 Second winding head region
12 First heat exchanger
13 Cooling groove
14 First main line
15 Second main line
16 First vent line
17 Second vent line
18 Bypass line
19 First bypass line connection
20 Second bypass line connection
21 Third bypass line connection
22 Earth gravity field
23 Highest point of the AC housing
24 Highest point of the first winding head region
25 Highest point of the second winding head region
26 Oil filter
27 Connecting line
28 Thermal management module
29 Drive train
30 Transmission
31 Oil circuit
32 First circulation direction
33 Second circulation direction
34 Second heat exchanger
35 Water circuit
36 Third circulation direction
37 Third heat exchanger
38 Pulse inverter
39 Environment
40 Drive wheel
41 Chassis
42 Transport chamber
43 Transmission component
44 Oil sump
45 Coarse filter
46 Second circulation pump
47 Compensation tank
48 Gas
49 Volume compensation tank
50 Stator lamination pack
51 Temperature sensor
52 Differential
53 Processor

Claims

1. A cooling system for an electric traction machine for a motor vehicle, comprising at least the following components:

- a circuit system for conducting a first coolant to be circulated;
- a first circulation pump for conveying the first coolant in the circuit system;
- an AC housing for an AC connection for the electric traction machine;

wherein the electric traction machine is to be temperature controlled and comprises an input side and an output side; the cooling system further comprising:

- a motor inlet connection for fluidly connecting the circuit system on the input side to the electric traction machine to be temperature-controlled;
- a motor outlet connection for fluidly connecting the circuit system on the output side to the electric traction machine to be temperature-controlled; and
- a first heat exchanger for dissipating heat from and/or supplying heat to the first coolant to be circulated in the circuit system,

wherein

a first main line is provided, by means of which the first heat exchanger and the AC housing are fluidly connected to one another.

2. The cooling system according to claim 1, wherein

the first main line is connected to the AC housing at the highest point in a normal orientation of the AC housing in the earth gravity field.

3. The cooling system according to claim 2, wherein the highest point of the AC housing in the normal orientation is the same as or higher than at least one of the following components:

- the motor inlet connection;

- the motor outlet connection; and
- a different line section of the circuit system.

4. The cooling system according to any one of the preceding claims, wherein

   the first main line is arranged upstream of a filter arranged behind the first heat exchanger.

5. The cooling system according to any one of the preceding claims, wherein

   a first vent line is provided between the AC housing and one of the winding head regions of the electric traction machine to be temperature-controlled.

6. The cooling system according to claim 5, wherein the first vent line is provided between the AC housing and the first of the winding head regions.

7. The cooling system according to claim 5 or 6, wherein the first vent line is indirectly or directly fluidly connected to at least one of the following highest points in the earth gravity field in a normal orientation of the cooling system:

- with the highest point of the AC housing;
- with the highest point of a first winding head region of the electric traction machine to be temperature-controlled; and
- with the highest point of a second winding head region of the electric traction machine to be temperature-controlled.

8. The cooling system according to any one of the preceding claims, wherein

   a second vent line is provided, by means of which, in a normal orientation of the electrical traction machine in the earth gravity field, the respective highest points of winding head regions of the electrical traction machine to be temperature-controlled are fluidly connected to one another.

9. A thermal management module for a powertrain of a motor vehicle, comprising at least the following components:

- for a transmission, an oil circuit having a second circulation direction and having a second heat exchanger;

- for at least one vehicle component, a water circuit having a third circulation direction and having a third heat exchanger; and

  for an electric traction machine, a cooling system according to any one of the preceding claims.

10. A thermal management module according to claim 9, wherein, a pulse inverter for the electric traction machine is arranged in the water circuit.

11. The thermal management module according to claim 9 or claim 10, wherein

    the water circuit is connected to the first heat exchanger of the cooling system for an electric traction machine for heat transfer.

12. The thermal management module according to claim 11, wherein the water circuit is connected to the first heat exchanger of the cooling system for an electric traction machine for heat transfer as the only liquid-bonded heat transfer of the cooling system to the environment.

13. The thermal management module according to claim 11 or claim 12 wherein, in the third circulation direction of the water circuit, a pulse inverter for an electric traction machine is arranged upstream of the first heat exchanger.

14. The thermal management module according to any one of claims 11 to 13, wherein

    the water circuit is additionally connected to the second heat exchanger of the oil circuit for heat transfer.

15. The thermal management module according to claim 14, wherein the water circuit is additionally connected to the second heat exchanger of the oil circuit for heat transfer as the only liquid-bonded heat transfer of the cooling system to the environment.

16. The thermal management module according to claim 14 or 15, wherein, in the third circulation direction of the water circuit, the first heat exchanger is arranged upstream of the second heat exchanger.

17. A powertrain for a motor vehicle, comprising at least the following components:

- at least one electric traction machine for providing a torque;
- at least one propulsion wheel for propelling the relevant motor vehicle by means of a torque of the electric traction machine;
- at least one transmission for conducting a torque between the electric traction machine and at least one of the propulsion wheels; and
- a cooling system according to any one of claims 1 to 8 for at least one of the electric traction machines and/or a thermal management module according to any one of claims 9 to 16 for at least one of the electric traction machines, at least one of the transmissions, and at least one vehicle component.

18. The powertrain according to claim 17, wherein the at least one vehicle component comprises a pulse inverter for at least one of the electric traction machines.

19. A motor vehicle comprising a chassis having a transport cell and a powertrain according to claim 17 or 18 for driving the motor vehicle forward.