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United States Patent	12388327
Kind Code	B2
Date of Patent	August 12, 2025
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Electric machine for an electric vehicle

Abstract

An electric machine includes a housing, a stator rigidly arranged on the housing, a rotor rotatably supported on the housing, and a canned tube. The stator and rotor bound a radial gap. The canned tube fluid-tightly abuts the housing such that the canned tube fluid-tightly separates a wet space through which a coolant can flow from a dry space. The stator and rotor are arranged in the wet and dry spaces, respectively. The canned tube on an outer peripheral surface and/or the stator on an inner peripheral surface includes an elastically deformable sealing element. The sealing element is elastically deformed in a finally mounted state of the canned tube between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator such that a gap between the outer peripheral surface and the inner peripheral surface of the stator is sealed.

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Appl. No.:	18/351509
Filed:	July 13, 2023

Prior Publication Data

Document Identifier	Publication Date
US 20240022138 A1	Jan. 18, 2024

Foreign Application Priority Data

DE	10 2022 117 850.1	Jul. 18, 2022
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Publication Classification

Int. Cl.: H02K9/197 (20060101); H02K5/20 (20060101)

U.S. Cl.:

CPC H02K9/197 (20130101); H02K5/203 (20210101);

Field of Classification Search

CPC: H02K (9/19); H02K (9/197); H02K (9/00); H02K (5/20); H02K (5/203); H02K (5/02); H02K (5/04); H02K (5/00)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
4227108	12/1979	Washizu	310/58	H02K 5/128
9130417	12/2014	Bode	N/A	H02K 5/128
2014/0139061	12/2013	Gutjahr	310/86	H02K 9/197
2021/0218316	12/2020	Ness	N/A	H02K 5/203

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
1802561	12/1969	DE	N/A
1802561	12/1969	DE	N/A
202005021025	12/2006	DE	H02K 5/08
202011103647	12/2011	DE	N/A
102020101316	12/2020	DE	N/A

OTHER PUBLICATIONS

Machine Translation of DE 1802561 A1 (Year: 1970). cited by examiner

Machine Translation of DE_202005021025_U1 (Year: 2006). cited by examiner

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS

(1) This application claims benefit to German Patent Application No. DE 10 2022 117 850.1, filed on Jul. 18, 2022, which is hereby incorporated by reference herein.

FIELD

(2) The invention relates to an electric machine for an electric vehicle, with a housing and a stator rigidly arranged in the housing, and a rotor rotatably supported on the housing.

BACKGROUND

(3) Electric machines, also known as canned motors, are well known. For example, DE 2020 101

316 A1 discloses such an electric machine. The electric machine comprises a rotor having a rotor sheet package and a stator. Furthermore, the electric machine comprises a canned tube made of plastic arranged in a radial gap between an inner peripheral surface of the stator and an outer peripheral surface of the rotor. The canned tube serves to seal a wet space through which a coolant flows from a dry space, wherein the stator is arranged in the wet space and the rotor is arranged in the dry space. In this way, the stator that heats up during operation can be cooled directly by a coolant, wherein the coolant flows around the coil heads on the one hand and around the stator coils extending through the stator grooves on the other hand. The coolant flows through the stator grooves. The canned tube is connected to the stator via the outer peripheral surface. For this purpose, a resin coating, which is also used for sealing between the stacked stator sheets, is provided on the outer peripheral surface of the canned tube, wherein the canned tube is mounted on the stator and a material-locking connection is established via the resin coating between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator. This fluid-tightly seals the gap between the inner peripheral surface of the stator and the outer peripheral surface of the canned tube. Alternatively, the canned tube can be attached to the stator via a press-fit or an adhesive connection, i.e., via a material-locking connection. Such an embodiment is disclosed, for example, by DE 20 2005 021 025 U1.

(4) One disadvantage of a press-fit between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator is that a fluid-tight connection between the outer peripheral surface of the canned tube and the inner peripheral surface cannot be reliably prevented. In the operation of the electric machine, temperature fluctuations occur, thereby causing thermal expansions of the components, in particular of the canned tube and the stator, wherein the thermal expansion of the canned tube deviates relatively strongly from the thermal expansion of the stator, i.e., the stator sheet package, due to the material deviating from the stator, and the pressing between the outer peripheral surface of the canned tube and the inner peripheral surface can thereby be reduced in such a way that leakage through the gap between the stator and the canned tube cannot be reliably prevented. In addition, the coolant is introduced into the wet space at a certain pressure, so that the coolant is also present in the region of the abutment between the canned tube and the stator in case of pressure, thereby pushing the coolant into the gap.

(5) The material-locking connection of the canned tube to the stator, in particular by the resin coating or the glue, leads to an undesirable mechanical stress on the canned tube. The mechanical stress is caused by the deviating thermal expansions of different components of the electric machine. The canned tube is attached to the stator on the one hand in a material-locking manner and on the other hand to a housing in a fluid-tight manner at both axial ends. In the event of temperature fluctuations in the operation of the electric machine, the canned tube and the different components abutting the canned tube, in particular the stator sheet package and the housing, expand in deviation from one other, thereby mechanically stressing the canned tube attached to both components.

SUMMARY

(6) In an embodiment, the present disclosure provides an electric machine for an electric vehicle, comprising a housing, a stator rigidly arranged on the housing, a rotor rotatably supported on the housing, and a canned tube. The stator and the rotor bound a radial gap. The canned tube fluid-tightly abuts the housing at an end such that the canned tube fluid-tightly separates a wet space through which a coolant can flow from a dry space. The stator is arranged in the wet space and the rotor is arranged in the dry space. The canned tube on an outer peripheral surface and/or the stator on an inner peripheral surface comprises an elastically deformable sealing element. The sealing element is elastically deformed in a finally mounted state of the canned tube between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator such that a gap between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator is sealed.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Subject matter of the present disclosure will be described in even greater detail below based on the exemplary figures. All features described and/or illustrated herein can be used alone or combined in different combinations. The features and advantages of various embodiments will become apparent by reading the following detailed description with reference to the attached drawings, which illustrate the following:

(2) FIG. 1 schematically shows an electric machine of an electric vehicle in cross-section.

DETAILED DESCRIPTION

(3) In an embodiment, the present invention provides an electric machine by which the gap between the stator and the canned tube can be reliably sealed and the mechanical stress of the canned tube can be reduced.

(4) In an embodiment, an electric machine for an electric vehicle is provided with a housing, a stator rigidly arranged on the housing, a rotor rotatably supported on the housing, wherein the stator and the rotor bound a radial gap, and a canned tube arranged in the radial gap and fluid-tightly abutting the housing at the end in such a way that the canned tube fluid-tightly separates a wet space through which a coolant can flow from a dry space, and wherein the stator is arranged in the wet space and the rotor is arranged in the dry space.

(5) Due to the fact that the canned tube on an outer peripheral surface and/or the stator on an inner peripheral surface comprises an elastically deformable sealing element, wherein the sealing element is elastically deformed in the finally mounted state of the canned tube between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator in such a way that a gap between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator is sealed in a fluid-tight manner, the gap between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator can be reliably sealed by the elastically deformed sealing element, on the one hand, and the thermal expansions of different components occurring during operation of the electric machine can be permitted by the flexibility of the sealing element and/or a displacement of the canned tube, on the other hand. The displacement of the canned tube is possible, because the sealing element does not form a material-locking connection between the canned tube and the stator.

(6) Preferably, the sealing element is configured as a coating, wherein the coating is applied to the outer peripheral surface of the canned tube and/or to the inner peripheral surface of the stator. The coating can be applied during the manufacture of the stator and/or the canned tube, wherein the canned tube need only be inserted into an opening radially bounded by the inner peripheral surface during final assembly of the electric machine. The sealing element thereby deforms when the canned tube is inserted into the opening. In this way, assembly can be simplified.

(7) In a preferred configuration, the sealing element is made of an elastomer, wherein the elastomer can conform to the corresponding abutment surface, and thereby the gap between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator can be reliably sealed. In addition, the elastomer is flexible such that the thermal expansions created during operation can be accommodated by the elastic deformation of the sealing element.

(8) Preferably, the wet space on a first end face of the stator comprises a coolant inlet and on a second end face comprises a coolant outlet, wherein the sealing element is provided exclusively on a portion of the outer peripheral surface of the canned tube facing the coolant inlet and/or the inner peripheral surface of the stator. As a result, manufacturing costs can be reduced, and sealing of the gap between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator can continue to occur in a reliable manner. A pressure-based penetration into the gap can thereby be prevented.

(9) In a preferred configuration, the sealing element extends over the entire abutment portion between the canned tube and the stator. Thus, the gap between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator can be particularly reliably sealed. In an embodiment, the sealing element extends axially beyond the abutment portion between the canned tube and the stator, wherein a collar is formed in the deformed state of the sealing element in the region outside the abutment portion, i.e., in the non-deformed region. This further improves the sealing.

(10) Preferably, the canned tube is made of a fiber-reinforced plastic, in particular a fiber glass-reinforced plastic. The canned tube can thus be manufactured with a low weight. In addition, the canned tube can be manufactured simply and in a time-saving manner.

(11) In a preferred embodiment, the stator comprises a plurality of stator grooves distributed circumferentially, in which at least one stator coil is arranged, wherein the stator grooves are configured so as to be closed at the inner peripheral surface. By means of the closed stator grooves, a radial stress of the canned tube can be prevented by the coolant flowing in the stator grooves, so that the canned tube is subjected to less mechanical stress and the wall thickness can thereby be designed smaller. The reduced wall thickness can reduce the radial extension of the radial gap, thereby increasing the efficiency of the electric machine.

(12) Preferably, the canned tube abuts the housing on the end side via a respective seal, whereby the dry space can be reliably sealed against the wet space.

(13) An electric machine is thus provided, in which, on the one hand, the gap between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator can be reliably sealed by the elastically deformable sealing element and, on the other hand, the stresses of the canned tube caused by the thermal expansions can be reduced.

(14) An exemplary embodiment of the invention will now be explained in further detail with reference to the drawing.

(15) FIG. 1 shows an electric machine **10** of an electric vehicle, which is used in particular as a traction machine of an electric vehicle. The electric machine **10** comprises a housing **12**, which comprises a housing base body **14** and a lid **16** and bounds a housing interior **15**. A stator **18** and a rotor **20** are arranged in the housing **12**, i.e., in the housing interior **15**. The stator **18** is fixed to the housing **12** over the outer peripheral surface **26**, i.e., to a housing wall of the housing base body **14**, via the outer peripheral surface and is thus rigidly arranged in the housing interior. The stator **18** comprises a plurality of stator grooves **19** distributed circumferentially, in which a stator coil **21** is arranged. The stator grooves **19** extend between the two end faces of the stator **18**, wherein the stator grooves **19** are closed at an inner peripheral surface **28** of the stator **18**. The inner peripheral surface **28** of the stator **18** bounds a through-opening in which the rotor is arranged. The rotor **20** comprises a rotor shaft **22** and a rotor core **24**, wherein the rotor core **24** is in particular configured as a rotor sheet package and comprises a plurality of embedded permanent magnets. The rotor shaft **22** is rotatably supported on the housing **12**, wherein a respective bearing element **40**, **42** is arranged on both axial ends of the rotor shaft **22**. The rotor core **24** is attached to a peripheral surface of the rotor shaft **22** and rotates along with the rotor shaft **22**.

(16) The electric machine **10** further comprises a canned tube **50** arranged in a radial gap between the stator **18** and the rotor **20**. The radial gap **30** is thereby radially bounded by the inner peripheral surface **28** of the stator **18** and an outer peripheral surface **32** of the rotor **20**. The canned tube **50** is made of a fiber composite, in particular a fiber glass-reinforced plastic, and extends through the radial gap **30**, wherein the canned tube **50** projects beyond the front faces of the stator **18** and is fixed to the housing **12** in the axial direction on both sides in a fluid-tight manner. The canned tube **50** has an outer peripheral surface **54** facing the stator **18** and an inner peripheral surface **52** facing the rotor **20**. A seal **62**, **64** is arranged on two opposite sides of the housing **12** in order to fluid-tightly connect the canned tube **50** to the housing **12**. Thus, the canned tube **50** divides the housing interior **15** into a wet space **58** and a dry space **60**. The stator **18** is arranged in the wet space **58**.

The rotor **20** is arranged in the dry space **60**.

(17) In addition to the end-sided attachment of the canned tube **50** to the housing **12**, the canned tube **50** is radially supported on the stator **18**, wherein the canned tube **50** is supported with an outer peripheral surface **54** on the inner peripheral surface **28** of the stator **18**. The canned tube **50** has a sealing element **56** on the outer peripheral surface **54** of the canned tube **50**, which is manufactured from an elastomer and is applied to the outer peripheral surface **54** of the canned tube **50** via a coating process.

(18) During operation of the electric machine **10**, the stator **18**, in particular the stator coils **21**, heat up. In order to cool, i.e., to remove heat from the stator **18** or stator coils **21**, the wet space **58** has a coolant inlet **68** and a coolant outlet **66**, wherein the coolant inlet **68** is arranged at a first end face of the stator **18** and the coolant outlet **66** is arranged at a second end face of the stator **18**. The coolant inlet **68** and the coolant outlet **66** are fluid-tightly connected to a cooling system **70**. The cooling system **70** comprises a heat exchanger **72** and a pump **74**. A coolant is pumped through the pump **74** to the coolant inlet **68** and thus into the wet space **58**. The coolant then flows through the stator grooves **19** from the first end face of the stator **18** to the second end face of the stator **18**. Finally, the coolant flows out of the wet space **58** via the coolant outlet **66** and flows to the heat exchanger **72**, where the heat received from the coolant is dissipated.

(19) It is essential that the coolant for cooling the stator coil **21** flows exclusively through the stator grooves **19**, and a leakage at other points is avoided. In particular, the coolant should not flow via the gap **55** between the inner peripheral surface **28** of the stator **18** and the outer peripheral surface **54** of the canned tube **50** from the first end face to the second end face of the stator **18**, i.e., a penetration of the coolant into the gap **55** should be avoided as much as possible. This is achieved by the sealing element **56**, which is attached to the canned tube **50** in a fluid-tight manner, wherein the sealing element **56** is applied to the outer peripheral surface **54** of the canned tube **50** in the form of a coating and, in the finally assembled state, abuts the inner peripheral surface **28** of the stator **18** in an elastically deformed manner. The sealing element **56** is provided over the entire abutment surface between the stator **18** and the canned tube **50** and even projects axially beyond the abutment surface.

(20) It is further critical that the stress on the canned tube **50** caused by the temperature fluctuations during operation of the electric machine **10** or by the thermal expansions of the rotor core **24** and the housing **12** caused by the temperature variations is kept as low as possible. This is achieved by the fact that the canned tube **50** is not connected to the stator **18** in a material-locking manner and the elastically deformable sealing element **56** can accommodate the thermal expansions or allow a displacement of the canned tube **50**.

(21) In addition or alternatively, a sealing element could also be provided on the inner peripheral surface **28** of the stator **18**. Furthermore, the sealing element could also only be provided on a portion abutting the first end face so that the gap **55** is only sealed on the coolant inlet side.

(22) Structural embodiments other than the described embodiments are possible as well. For example, the canned tube **50** could also be made of a carbon fiber-reinforced plastic. In addition, the sealing element **56** could also be made of a different material and/or glued to the canned tube **50**.

(23) While subject matter of the present disclosure has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. Any statement made herein characterizing the invention is also to be considered illustrative or exemplary and not restrictive as the invention is defined by the claims. It will be understood that changes and modifications may be made, by those of ordinary skill in the art, within the scope of the following claims, which may include any combination of features from different embodiments described above.

(24) The terms used in the claims should be construed to have the broadest reasonable interpretation consistent with the foregoing description. For example, the use of the article “a” or

“the” in introducing an element should not be interpreted as being exclusive of a plurality of elements. Likewise, the recitation of “or” should be interpreted as being inclusive, such that the recitation of “A or B” is not exclusive of “A and B,” unless it is clear from the context or the foregoing description that only one of A and B is intended. Further, the recitation of “at least one of A, B and C” should be interpreted as one or more of a group of elements consisting of A, B and C, and should not be interpreted as requiring at least one of each of the listed elements A, B and C, regardless of whether A, B and C are related as categories or otherwise. Moreover, the recitation of “A, B and/or C” or “at least one of A, B or C” should be interpreted as including any singular entity from the listed elements, e.g., A, any subset from the listed elements, e.g., A and B, or the entire list of elements A, B and C.

Claims

1. An electric machine for an electric vehicle, comprising: a housing; a stator rigidly arranged on the housing; a rotor rotatably supported on the housing, wherein the stator and the rotor bound a radial gap; and a canned tube arranged in the radial gap and fluid-tightly abutting the housing at an end such that the canned tube fluid-tightly separates a wet space through which a coolant can flow from a dry space, wherein the stator is arranged in the wet space and the rotor is arranged in the dry space, wherein the canned tube on an outer peripheral surface and/or the stator on an inner peripheral surface comprises an elastically deformable sealing element, wherein the sealing element is elastically deformed in a finally mounted state of the canned tube between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator such that a gap between the outer peripheral surface of the canned tube and the inner peripheral surface of the stator is sealed.
 2. The electric machine according to claim 1, wherein there is no material-locking connection between the canned tube and the stator.
 3. The electric machine according to claim 1, wherein the sealing element is configured as a coating, and wherein the coating is applied to the outer peripheral surface of the canned tube and/or to the inner peripheral surface of the stator.
 4. The electric machine according to claim 1, wherein the sealing element is made from an elastomer.
 5. The electric machine according to claim 1, wherein the wet space on a first end face of the stator comprises a coolant inlet and on a second end face of the stator comprises a coolant outlet, and wherein the sealing element is provided exclusively on a portion of the outer peripheral surface of the canned tube facing the coolant inlet and/or the inner peripheral surface of the stator.
 6. The electric machine according to claim 1, wherein the sealing element extends across an entire abutment portion between the canned tube and the stator.
 7. The electric machine according to claim 1, wherein the canned tube is manufactured from a fiber-reinforced plastic.
 8. The electric machine according to claim 1, wherein the stator comprises a plurality of stator grooves distributed circumferentially, in which at least one stator coil is arranged, and wherein the stator grooves are configured to be closed at the inner peripheral surface.
 9. The electric machine according to claim 1, wherein the canned tube abuts the housing on an end side via a respective seal.
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