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ELECTRIC MOTOR

Abstract

An electric motor of the present disclosure may include: a housing; a stator positioned inside the housing; and a rotor positioned inside the stator, wherein the stator may include: a core having a hollow cylindrical shape, the core including a slot formed by penetrating both ends of the core in an axial direction of the core; a coil wound around the slot and through which a current flows; and a sleeve extending along the slot and covering a lateral surface of the coil, the sleeve forming a path between the sleeve and the coil, wherein the core may include a hole formed from an outer circumferential surface of the core toward the slot, and communicating with the path of the sleeve, wherein the housing may include an oil inlet formed at the housing.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] Pursuant to 35 U.S.C. § 119, this application claims the benefit of earlier filing date and right of priority to Korean Patent Application No. 10-2024-0021118 filed on Feb. 14, 2024, and International Application No. PCT/KR2024/015965, filed on Oct. 21, 2024, the contents of which are all hereby incorporated by reference herein in their entireties.

BACKGROUND OF THE INVENTION

Field of the invention

[0002] The present disclosure relates to an electric motor. More particularly, the present disclosure relates to an electric motor with improved cooling performance.

Description of the Related Art

[0003] An electric motor is a device that converts electric energy into rotational kinetic energy. By electromagnetic interaction between the stator and rotor of the electric motor, the rotor rotates at a high speed. The torque generated by the electric motor may be provided to various products such as an electric vehicle and the like. Recently, with the rapid growth of the electric vehicle (EV) market, high-power, high-speed electric motor is actively researched.

[0004] However, it is difficult to improve performance of the electric motor due to heat generated by the electric motor. Particularly, it is difficult to effectively cool a stator coil on which a hot spot is formed.

SUMMARY OF THE INVENTION

[0005] It is an objective of the present disclosure to solve the above and other problems.

[0006] Another object of the present disclosure may be to provide an electric motor with improved cooling performance.

[0007] Another object of the present disclosure may be to provide a structure for directly cooling a stator coil with oil.

[0008] Another object of the present disclosure may be to provide a structure for directly cooling a coil from the center to both ends thereof with oil.

[0009] Another object of the present disclosure may be to provide a structure of a core of a stator that provides a path of oil.

[0010] Another object of the present disclosure may be to provide a holder for providing a path of oil that directly cools a coil.

[0011] Another object of the present disclosure may be to provide a holder for fixing the position of a coil while providing electrical isolation between the coil and a core of a stator.

[0012] Another object of the present disclosure may be to provide a structure for increasing cooling efficiency of a stator by forming a zigzag path of oil at the center of a core.

[0013] Another object of the present disclosure may be to provide a structure for fixing an end-turn portion of a coil.

[0014] Another object of the present disclosure may be to provide a structure for reducing the volume of an electric motor and the manufacturing cost of the electric motor.

[0015] In accordance with an aspect of the present disclosure for achieving the above and other objectives, an electric motor may include: a housing; a stator positioned inside the housing; and a rotor positioned inside the stator, wherein the stator includes: a core having a hollow cylindrical

shape, the core including a slot formed by penetrating both ends of the core in an axial direction of the core; a coil wound around the slot and through which a current flows; and a sleeve extending along the slot and covering a lateral surface of the coil, the sleeve forming a path between the sleeve and the coil, wherein the core includes a hole formed from an outer circumferential surface of the core toward the slot, and communicating with the path of the sleeve, wherein the housing may include an oil inlet formed at the housing.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIGS. **1** to **26** are diagrams illustrating examples of an electric motor according to embodiments of the present disclosure.

DETAILED DESCRIPTION

[0017] Hereinafter, the present disclosure will be described in detail with reference to the accompanying drawings, in which the same reference numerals are used throughout the drawings to designate the same or similar components, and a redundant description thereof will be omitted.

[0018] The suffixes, such as “module” and “unit,” for elements used in the following description are given simply in view of the case of the description, and do not have a distinguishing meaning or role.

[0019] In addition, it will be noted that a detailed description of known arts will be omitted if it is determined that the detailed description of the known arts can obscure the embodiments of the present disclosure. Further, the accompanying drawings are used to help easily understand various technical features and it should be understood that the embodiments presented herein are not limited by the accompanying drawings. As such, the present disclosure should be construed to extend to any alterations, equivalents and substitutes in addition to those which are particularly set out in the accompanying drawings.

[0020] It will be understood that, although the terms first, second, etc., may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another.

[0021] It will be understood that when an element is referred to as being “connected” or “coupled” to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being “directly connected” or “directly coupled” to another element, there are no intervening elements present.

[0022] A singular representation may include a plural representation unless context clearly indicates otherwise.

[0023] It should be understood that the terms “comprise,” “include,” “have,” etc. when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components, or combinations thereof but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, or combinations thereof.

[0024] References to directions, such as up (U), down (D), left (Le), right (Ri), front (F), and rear (R), shown in the drawings are provided merely for convenience of explanation and are not intended for limiting the scope of the present disclosure.

[0025] Referring to FIG. **1**, an electric motor M may include a stator **1** and a rotor **2**.

[0026] The stator **1** may have a hollow cylindrical shape. A coil **30** may be wound around the stator **1**, and a current may flow through the coil **30**. The coil **30** may be a component of the stator **1**. A housing **3** may cover a lateral surface of the stator **1**.

[0027] The rotor **2** may be located inside the stator **1** and may have a cylindrical shape. The rotor **2** may have magnet(s), and when a current flows through the coil **30** of the stator **1**, the rotor **2** may rotate relative to the stator **1**. The magnet(s) may be a component of the rotor **2**. A shaft **4** may be

fixed to the center of the rotor **2** and may rotate together with the rotor **2**. A rotation axis A of the shaft **4** may be parallel to a front-rear direction. For example, the shaft **4** may be connected to a drive shaft of an electric vehicle.

[0028] Referring to FIG. **2**, the stator **1** may include a core **10**, a holder **20**, and the coil **30**.

[0029] The core **10** may be generally in the shape of a hollow cylinder. The core **10** may include a first side core **11**, a second side core **12**, and a middle core **13**. The first side core **11** may form a first end of the core **10**. The second side core **12** may form a second end of the core **10**. The middle core **13** may be disposed between the first side core **11** and the second side core **12**. The middle core **13** may form a central portion of the core **10**. The first side core **11** may be referred to as a front core **11**, the second side core **12** may be referred to as a rear core **12**, and the middle core **13** may be referred to as a central core **13**.

[0030] The holder **20** may be inserted into a slot **10**S of the core **10**. A portion **211** of a first holder **21** may be inserted into a slot **11***b* of the first side core **11**. A portion **221** of a second holder **22** may be inserted into a slot **12***b* of the second side core **12**. A slot **13***b* of the middle core **13** may provide a passage which connects an internal space of the portion **211** of the first holder **21** and an internal space of the portion **221** of the second holder **22**. Alternatively, the portion **211** of the first holder **21** and/or the portion **221** of the second holder **22** may also be inserted into the slot **13***b* of the middle core **13**. The slot **11***b* of the first side core **11** may form a first section **11***b* of the slot **10**S. The slot **12***b* of the second side core **12** may form a second section **12***b* of the slot **10**S. The slot **13***b* of the middle core **13** may form a third section **13***b* of the slot **10**S, and the third section **13***b* may connect the first and second sections **11***b* and **12***b*.

[0031] The coil **30** may be inserted into the holder **20** which is inserted into the slot **10**S of the core **10**. The coil **30** may pass through the internal space of the portion **211** of the first holder **21**, the slot **13***b* of the middle core **31**, and the internal space of the portion **221** of the second holder **22**. The coil **30** may be wound around the slot **10**S and the holder **20**. The coil **30** may be a hairpin coil **30**. The coil **30** may be referred to as a conductor **30** or a wire **30**.

[0032] Referring to FIGS. **3** and **4**, the first side core **11** may include a body **11***a*, a slot **11***b*, and a slit **11***c*.

[0033] The body **11***a* may have a hollow cylindrical shape. A length l**1** of the body **11***a* may be smaller than a radius r**1** of the body **11***a*. A thickness t**1** of the body **11***a* may be smaller than the length l**1** of the body **11***a*.

[0034] The slot **11***b* may be formed by penetrating both ends of the body **11***a* in an axial direction of the body **11***a*. That is, a length l**11** of the slot **11***b* may be equal to the length l**1** of the body **11***a*. The slot **11***b* may be adjacent to an inner circumferential surface **11***aa* of the body **11***a*. The slot **11***b* may extend in a direction intersecting the inner circumferential surface **11***aa* and an outer circumferential surface **11***ab* of the body **11***a*. The slot **11***b* may extend in a radial direction of the first side core **11**. A plurality of slots **11***b* may be spaced apart from each other in a circumferential direction of the body **11***a*.

[0035] The slit **11***c* may be formed in the inner circumferential surface **11***aa* of the body **11***a* and may face the slot **11***b*. The slot **11***b* may be opened toward the slit **11***c*. The slit **11***c* may be elongated along the slot **11***b*. A length l**12** of the slit **11***c* may be equal to the length l**11** of the slot **11***b*. A width w**12** of the slit **11***c* may be smaller than a width w**11** of the slot **11***b*. A plurality of slits **11***c* may be spaced apart from each other in the circumferential direction of the body **11***a* and may correspond to the plurality of slots **11***b*. Each of the plurality of slits **11***c* may be aligned with each of the plurality of slots **11***b*. The slit **11***c* and the slot **11***b* may be aligned with each other in the radial direction of the first side core **11**.

[0036] The first side core **11** may include plates stacked on top of each other. The first side core **11** is a set of thin plates and may be referred to as a first lamination (laminated) core **11**. The plates of the first side core **11** may be bonded to each other. The plate of the first side core **11** may be referred to as a sheet and may include a metal material such as steel. The plates forming the first

side core **11** may have the same shape, and may form the body **11***a*, the slot **11***b*, and the slit **11***c* described above.

[0037] Referring to FIGS. **5** and **6**, a second side core **12** may include a body **12***a*, a slot **12***b*, and a slit **12***c*.

[0038] The body **12***a* may have a hollow cylindrical shape. A length l**2** of the body **12***a* may be smaller than a radius r**2** of the body **12***a*. A thickness t**2** of the body **12***a* may be smaller than the length l**2** of the body **12***a*.

[0039] The slot **12***b* may be formed by penetrating both ends of the body **12***a* in an axial direction of the body **12***a*. That is, a length l**21** of the slot **12***b* may be equal to the length l**2** of the body **12***a*. The slot **12***b* may be adjacent to an inner circumferential surface **12***aa* of the body **12***a*. The slot **12***b* may extend in a direction intersecting the inner circumferential surface **12***aa* and an outer circumferential surface **12***ab* of the body **12***a*. The slot **12***b* may extend in a radial direction of the second side core **12**. A plurality of slots **12***b* may be spaced apart from each other in a circumferential direction of the body **12***a*.

[0040] The slit **12***c* may be formed in the inner circumferential surface **12***aa* of the body **12***a* and may face the slot **12***b*. The slot **12***b* may be opened toward the slit **12***c*. The slit **12***c* may be elongated along the slot **12***b*. A length l**22** of the slit **12***c* may be equal to the length l**21** of the slot **12***b*. A width w**22** of the slit **12***c* may be smaller than a width w**21** of the slot **12***b*. A plurality of slits **12***c* may be spaced apart from each other in the circumferential direction of the body **12***a* and may correspond to the plurality of slots **12***b*. Each of the plurality of slits **12***c* may be aligned with each of the plurality of slots **12***b*. The slit **12***c* and the slot **12***b* may be aligned with each other in the radial direction of the second side core **12**.

[0041] The second side core **12** may include plates stacked on top of each other. The second side core **12** is a set of thin plates and may be referred to as a second lamination (laminated) core **12**. The plates of the second side core **12** may be bonded to each other. The plate of the second side core **12** may be referred to as a sheet and may include a metal material such as steel. The plates forming the second side core **12** may have the same shape, and may form the body **12***a*, the slot **12***b*, and the slit **12***c* described above.

[0042] Referring back to FIGS. **3** to **6**, the first side core **11** and the second side core **12** may have the same structure, shape, and material. In other words, the first and second side cores **11** and **12** may be side cores of one type. The first and second side cores **11** and **12** may be collectively referred to as the side core.

[0043] Referring to FIGS. **7** and **8**, the middle core **13** may include a body **13***a*, a slot **13***b*, and a hole **13***c*.

[0044] The body **13***a* may have a ring shape. A length l**3** of the body **13***a* may be smaller than a radius r**3** of the body **13***a*. A thickness t**3** of the body **13***a* may be greater than the length l**3** of the body **13***a* and may be smaller than the radius r**3** of the body **13***a*.

[0045] The slot **13***b* may be formed by penetrating both ends of the body **13***a* in an axial direction of the body **13***a*. That is, a length l**31** of the slot **13***b* may be equal to the length l**3** of the body **13***a*. The slot **13***b* may be adjacent to an inner circumferential surface **13***aa* of the body **13***a*. The slot **13***b* may extend in a direction intersecting the inner circumferential surface **13***aa* and an outer circumferential surface **13***ab* of the body **13***a*. The slot **13***b* may extend in a radial direction of the middle core **13**. A plurality of slots **13***b* may be spaced apart from each other in a circumferential direction of the body **13***a*.

[0046] The hole **13***c* may be formed in the outer circumferential surface **13***ab* of the body **13***a* and may face the slot **13***b*. The hole **13***c* may extend from the outer circumferential surface **13***ab* of the body **13***a* in a radial direction of the middle core **13**. The slot **13***b* may be opened toward the hole **13***c*. The hole **13***c* may be formed along the slot **13***b*. A width w**32** of the hole **13***c* may be smaller than a width w**31** of the slot **13***b*. A plurality of holes **13***c* may be spaced apart from each other in the circumferential direction of the body **13***a* and may correspond to the plurality of slots **13***b*. Each

of the plurality of holes **13***c* may be aligned with each of the plurality of slots **13***b*.
[0047] A gum **13***g* may form the inner circumferential surface **13***aa* of the body **13***a* and may form a closed loop. Teeth **13***t* may protrude from the gum **13***g* to form the outer circumferential surface **13***ab* of the body **13***a* and may be arranged along the gum **13***g*. The slot **13***b* and the hole **13***c* may be formed between the teeth **13***t*. That is, the teeth **13***t* and the plurality of slots **13***b* may be arranged alternately. A rib **13***r* may be positioned in the hole **13***c* and may connect the teeth **13***t* that are next to each other. The rib **13***r* positioned between a first tooth **13***t* and a second tooth **13***t* may protrude from the first tooth **13***t* toward the second tooth **13***t*. A first end of the rib **13***r* may be fixed to the first tooth **13***t*, and a second end of the rib **13***r* may be fixed to the second tooth **13***t*. A plurality of ribs **13***r* may be positioned in the plurality of holes **13***d*. The body **13***a* may include the gum **13***g*, the teeth **13***t*, and the rib **13***r*, thereby improving rigidity of the body **13***a*.
[0048] The middle core **13** may include plates stacked on top of each other. The middle core **13** is a set of thin plates and may be referred to as a lamination (laminated) core **13**. The plates of the middle core **13** may be bonded to each other. The plate of the middle core **13** may be referred to as a sheet and may include a metal material such as steel. The plates forming the middle core **13** may have the same shape, and may form the body **13***a*, the slot **13***b*, and the hole **13***c* described above.
[0049] Referring to FIGS. **8** to **10**, the middle core **13** may be divided into a first middle core **131** and a second middle core **132** in an axial direction of the middle core **13**. The first middle core **131** may form a first end **13**V of the middle core **13**, and the second middle core **132** may form a second end **13**W of the middle core **13**. The first end **13**V of the middle core **13** may be referred to as a first side **13**V of the middle core **13** and may face the first side core **11** (see FIG. **2**). The second end **13**W of the middle core **13** may be referred to as a second side **13**W of the middle core **13** and may face the second side core **12** (see FIG. **2**). A boundary line **13**L between the first middle core **131** and the second middle core **132** lies in the middle of the first and second sides **13**B and **13**W and may be formed in a circumferential direction of the middle core **13**. For example, both of a distance between the boundary line **13**L and the first side **13**V and a distance between the boundary line **13**L and the second side **13**W may be 2.5 mm. Each of the first and second middle cores **131** and **132** may be a set of thin plates.
[0050] The first middle core **131** may be referred to as first plates **131** stacked on top of each other. The ribs **13***r* of the first middle core **131** may be adjacent to the first side **13**V and may be spaced apart from each other in a depth direction DR of the hole **13***c*. The ribs **13***r* may be positioned in each of the holes **13***c* of the first middle core **131**. For example, the number of the ribs **13***r* positioned in any one hole **13***c* of the first middle core **131** may be two.
[0051] The second middle core **132** may be referred to as second plates **132** stacked on top of each other. The ribs **13***r* of the second middle core **132** may be adjacent to the second side **13**W and may be spaced apart from each other in the depth direction DR of the hole **13***c*. The ribs **13***r* may be positioned in each of the holes **13***c* of the second middle core **132**. For example, the number of the ribs **13***r* positioned in any one hole **13***c* of the second middle core **132** may be two.
[0052] The ribs **13***r* of the first middle core **131** and the ribs **13***r* of the second middle core **132**, which are positioned in any one hole **13***c* of the middle core **13**, may be staggered with each other in the depth direction DR of the hole **13***c*.
[0053] Referring to FIG. **11** together with FIG. **8**, the holes **13***c* of the middle core **13** may include first holes **13***ca* and second holes **13***cb*. In the circumferential direction of the middle core **13**, the first holes **13***ca* may be spaced apart from each other, and the second holes **13***cb* may be arranged alternately with the first holes **13***ca*.
[0054] The ribs **13***r* of the first middle core **131** may be adjacent to the first side **13**V and may include first ribs **13***ra* and third ribs **13***rc*. The first ribs **13***ra* may be positioned in each of the first holes **13***ca* and may be spaced apart from each other in a depth direction DR of the first hole **13***ca*. The third ribs **13***rc* may be positioned in each of the second holes **13***cb* and may be spaced apart from each other in a depth direction DR of the second hole **13***cb*. The first rib **13***ra* and the third rib

13*rc* may be located at different heights (levels) in the depth direction DR of the first hole **13***ca*. For example, the first rib **13***ra* may be located closer to the outer circumferential surface of the first middle core **131** than the third rib **13***rc*.

[0055] The ribs **13***r* of the second middle core **132** may be adjacent to the second side **13**W and may include second ribs **13***rb* and fourth ribs **13***rd*. The second ribs **13***rb* may be positioned in each of the first holes **13***ca* and may be spaced apart from each other in the depth direction DR of the first hole **13***ca*. The fourth ribs **13***rd* may be positioned in each of the second holes **13***cb* and may be spaced apart from each other in the depth direction DR of the second hole **13***cb*. The second rib **13***rb* and the fourth rib **13***rd* may be located at different heights (levels) in the depth direction DR of the second hole **13***cb*. For example, the fourth rib **13***rd* may be located closer to the outer circumferential surface of the second middle core **132** than the second rib **13***rb*.

[0056] Accordingly, the first ribs **13***ra* and the second ribs **13***rb* may be staggered with each other in the first holes **13***ca*. In addition, the third ribs **13***rc* and the fourth ribs **13***rd* may be staggered with each other in the second holes **13***cb*. The arrangement of the ribs **13***ra*, **13***rb*, **13***rc*, and **13***rd* may be referred to as a zigzag arrangement.

[0057] In the depth direction DR of the hole **13***c* of the middle core **13**, the height (level) of the second ribs **13***rb* of the second middle core **132** may be equal to the height (level) of the third ribs **13***ra* of the first middle core **131**. In the depth direction DR of the hole **13***c* of the middle core **13**, the height (level) of the fourth ribs **13***rd* of the second middle core **132** may be equal to the height (level) of the first ribs **13***ra* of the first middle core **131**.

[0058] In this case, by rotating the second middle core **132** by an angle theta **3** between the first hole **13***ca* and the second hole **13***cb* with respect to the first middle core **131** based on the axial direction of the middle core **13**, the second and fourth ribs **13***rb* and **13***rd* of the second middle core **132** may be aligned with the first and third ribs **13***ra* and **13***rc* of the first middle core **131**. In this manner, the second middle core **132** may be aligned with the first middle core **131**, unlike FIGS. **8** and **11**.

[0059] In other words, for a zigzag arrangement of the aforementioned ribs **13***ra*, **13***rb*, **13***rc*, and **13***rd* in the first and second middle cores **131** and **132** having the same shape, the second middle core **132** aligned with the first middle core **131** may be rotated with respect to the first middle core **131** by the angle theta **3** between the first hole **13***ca* and the second hole **13***cb*. In this manner, the second middle core **132** may be staggered with the first middle core **131** as illustrated in FIGS. **8** and **11**.

[0060] For example, the number of holes **13***c* of the middle core **13** may be **48**, and the angle theta **3** between the holes **13***c* may be 7.5 degrees (360 degrees/48). In this case, the ribs **13***ra*, **13***rb*, **13***rc*, and **13***rd* may be arranged in a zigzag arrangement by rotating the second middle core **132** relative to the first middle core **131** by 7.5 degrees or 172.5 degrees (=180 degrees−7.5 degrees) in the axial direction of the middle core **13**.

[0061] Referring to FIGS. **12** and **13**, the middle core **13** of the core **10** may be sandwiched between the first and second side cores **11** and **12**, and the middle core **13** may share a central axis A**1** with the first and second side cores **11** and **12**. A diameter of the middle core **13** may be equal to diameters of the first and side cores **11** and **12**. The length l**3** of the middle core **13** may be smaller than each of the lengths **11** and **12** of the first and second side cores **11** and **12** in the direction of the axis A**1** of the core **10**. In this case, the middle core **13** includes the gum **13***g* forming a closed loop, but the middle core **13** has a relatively small length l**3**, thereby minimizing performance deterioration of the electric motor M.

[0062] The plurality of slots **11***b* of the first side core **11**, the plurality of slots **12***b* (see FIG. **5**) of the second side core **12**, and the plurality of slots **13***b* (see FIG. **8**) of the middle core **13** may be aligned with each other in a direction parallel to the direction of the axis A**1** of the core **10**. The slots **11***b*, **12***b*, and **13***b* may have the same or corresponding shapes.

[0063] The first and second side cores **11** and **12** may block the holes **13***c* of the middle core **13** in

the direction parallel to the direction of the axis A**1** of the core **10**.
[0064] The first holder **21** may include a ring **210**, a sleeve **211**, and a protruding portion **212**.
[0065] The ring **210** may extend in the circumferential direction of the core **10**. The ring **210** may be located on one end of the core **10**, i.e., on a distal end of the first side core **11**. The ring **210** may extend along the slots **11***b* of the first side core **11** and may be disposed corresponding to the slots **11***b*. Through-holes **210***h* may be formed in the ring **210** and may be aligned with the slots **11***b*.
[0066] The sleeve **211** may protrude from the ring **210** toward the slot **11***b* and may be inserted into the slot **11***b*. The sleeve **211** may be elongated along the slot **11***b* and may have an internal space **211**S. A first end (inlet) of the internal space **211**S may face the through-hole **210***h* of the ring **210**, and a second end (outlet) of the internal space **211**S may face the slot **13***b* (see FIG. **8**) of the middle core **13**. The sleeve **211** may have a length equal to or corresponding to the length of the slot **11***b*. The sleeve **211** may have a cross-section corresponding to the shape of the slot **11**b. For example, the sleeve **211** may have a rectangular cross-section. A plurality of sleeves **211** may be arranged along the ring **210** and may be spaced apart from each other. Each of the plurality of sleeves **211** may be inserted into each of the plurality of slots **11***b*.
[0067] The protruding portion **212** may protrude from the ring **210** in a direction opposite the sleeve **211**. A protruding height of the protruding portion **212** that protrudes from the ring **210** may be smaller than the length of the sleeve **211**. A plurality of protruding portions **212** may be arranged along the ring **210** and may be spaced apart from each other. The plurality of protruding portions **212** may be staggered with the plurality of sleeves **211**. That is, the protruding portions **212** may be arranged alternately with the through-holes **210***h* in the circumferential direction of the ring **210**.
[0068] The first holder **21** may include a non-conductive material. For example, the first holder **21** may include a plastic or resin material. For example, the first holder **21** may be coupled to the first side core **11** by insert injection molding.
[0069] The second holder **22** may include a ring **220**, a sleeve **221**, and a protruding portion **222**.
[0070] The ring **220** may extend in the circumferential direction of the core **10**. The ring **220** may be located on another end of the core **10**, i.e., on a distal end of the second side core **12**. The ring **220** may extend along the slots **12***b* (see FIG. **5**) of the second side core **12**, and may be disposed corresponding to the slots **12***b*. Through-holes **220***h* may be formed in the ring **220** and may be aligned with the slots **12***b*.
[0071] The sleeve **221** may protrude from the ring **220** toward the slot **12***b* (sec FIG. **5**) and may be inserted into the slot **12***b*. The sleeve **221** may be elongated along the slot **12***b* and may have an internal space **221**S. A first end (inlet) of the internal space **221**S may face the through-hole **220***h* of the ring **220**, and a second end (outlet) of the internal space **221**S may face the slot **13***b* (see FIG. **8**) of the middle core **13**. The sleeve **221** may have a length equal to or corresponding to the length of the slot **12***b*. The sleeve **221** may have a cross-section corresponding to the shape of the slot **12***b*. For example, the sleeve **221** may have a rectangular cross-section. A plurality of sleeves **221** may be arranged along the ring **220** and may be spaced apart from each other. Each of the plurality of sleeves **221** may be inserted into each of the plurality of slots **12***b*.
[0072] The protruding portion **222** may protrude from the ring **220** in a direction opposite the sleeve **221**. A protruding height of the protruding portion **222** that protrudes from the ring **220** may be smaller than the length of the sleeve **221**. A plurality of protruding portions **222** may be arranged along the ring **220** and may be spaced apart from each other. The plurality of protruding portions **222** may be staggered with the plurality of sleeves **221**. That is, the protruding portions **222** may be arranged alternately with the through-holes **220***h* in the circumferential direction of the ring **220**.
[0073] The second holder **22** may include a non-conductive material. For example, the second holder **22** may include a plastic or resin material. For example, the second holder **22** may be coupled to the second side core **12** by insert injection molding.
[0074] For example, the first holder **21** and the second holder **22** may have the same structure, shape, and material. In other words, the first and second holders **21** and **22** may be holders of one

type. The first and second holders **21** and **22** may be collectively referred to as the holder **20**.
[0075] Referring to FIGS. **14** to **16**, the coil **30** may be inserted into the holder **20**. The coil **30** may be wound around the holder **20**. The holder **20** made of a non-conductive material may provide electrical insulation between the coil **30** and the core **10**. That is, insulation paper and/or varnish for electrical insulation between the coil **30** and the core **10** may be omitted, such that processing of the lamination (laminated) core **10** may be minimized, thereby minimizing performance deterioration of the core **10**. The coil **30** may include a plurality of pins **30**P.
[0076] For example, the pin **30** may have a hairpin shape. The pin **30**P may include a first portion **30**Pa, a second portion **30**Pb, and a third portion **30**Pc. The first portion **30**Pa may be inserted into the sleeve **211** (see FIG. **12**) of the first holder **21** and the sleeve **221** of the second holder **22** and may be elongated along the sleeves **211** and **221**. The second portion **30**Pb may be bent from the first portion **30**Pa and may have a V shape. The third portion **30**Pc may be bent from the second portion **30**Pb and may be parallel to the first portion **30**Pa. The third portion **30**Pc may be inserted into the sleeves **211** and **221** which are spaced apart from the sleeves **211** and **221** in which the first portion **30**Pa is inserted. The pin **30**P may be referred to as a hairpin **30**P, a U-shaped pin **30**P, a coil **30**P, a conductor **30**P, or a wire **30**P.
[0077] The protruding portions **222** of the second holder **22** may have a corrugated shape on the ring **220**. Some of the protruding portions **222** may be disposed between the first portion **30**Pa and the third portion **30**Pc of the pin **30**P. The second portion **30**Pb of the pin **30**P may be bent from the first and third portions **30**Pa and **30**Pc, and may be positioned on the protruding portion **222**. In this case, the second portion **30**Pb of the pin **30**P is held by the protruding portions **222** of the second holder **222**, such that movement of the pin **30**P in a direction from the second holder **22** to the first holder **21** may be restricted. The second portion **30**Pb of the pin **30**P may protrude by a predetermined height H**2** from the second holder **22**. A portion of the pin **30**P that protrudes from the second holder **22** may be referred to as a second end-turn portion **32**.
[0078] The protruding portions **212** of the first holder **21** may have a corrugated shape on the ring **210**. Some of the protruding portions **212** may be disposed between the first portion **30**Pa and the third portion **30**Pc of the pin **30**P. The first portion **30**Pa and the third portion **30**Pc of the pin **30**P may be bent or twisted outside the first holder **21**, and may be positioned on the protruding portion **212**. In this case, the first and third portions **30**Pa and **30**Pc of the pin **30**P are held by the protruding portions **212** of the first holder **21**, such that movement of the pin **30**P in a direction from the first holder **21** to the second holder **22** may be restricted. The first and third bent portions **30**Pa and **30**Pc of the pin **30**P may protrude by a predetermined height H**1** from the first holder **21**. A portion of the pin **30**P that protrudes from the first holder **21** may be referred to as a first end-turn portion **31**.
[0079] Accordingly, the coil **30** wound around the holder **20** may be coupled to the holder **20**. The pins **30**P of the coil **30** may be sequentially arranged in the circumferential direction of the holder **30**.
[0080] Referring to FIG. **17**, the sleeve **211** of the first holder **21** may be positioned in the slot **11***b* of the first side core **11**, and the plurality of pins **30**P of the coil **30** may be positioned in the internal space **211**S of the sleeve **211**. The sleeve **211** may include a body **211***a* and protrusions **211***b*.
[0081] The body **211***a* may cover the pins **30**P, and a cross-section of the body **211***a* may correspond to the shape of the slot **11***b*. The body **211***a* may have a rectangular cross-section. The body **211***a* may include two long sides LS**1** and LS**2** and two short sides SS**1** and SS**2**. The pins **30**P may be arranged along the long sides LS**1** and LS**2**. For example, the pins **30**P may form six layers. A direction in which the layers are stacked may be parallel to the radial direction of the core **10**.
[0082] The protrusions **211***b* may protrude from the body **211***a* toward the pins **30**P. The respective pins **30**P may have a rectangular cross-section. The protrusions **211***b* may be adjacent to four

corners of the respective pins **30**P. The protrusions **211***b* may contact the respective pins **30**P. The protrusion **211***b* may have a rounded distal end. Accordingly, the pins **30**P may be coupled to the sleeve **211**. That is, the position of the pins **30**P inside the sleeve **211** may be fixed even without varnish. In addition, a distance between the pins **30**P inside the sleeve **211** and an inner surface of the slot **13***b* of the middle core **13** may be maintained, such that electrical isolation may be maintained between the coil **30** and the core **10**.

[0083] A path **211**P may be formed between the body **211***a* and the pins **30**P. The path **211**P may be formed between the protrusions **211***b*. The path **211**P may surround the pins **30**P. The path **211**P may be the path **211**P of oil. That is, cooling oil may contact the pins **30**P to directly cool the pins **30**P.

[0084] The description of the sleeve **211** of the first holder **21** described above and to be described below nay also be applied to the sleeve **221** (see FIG. **12**) of the second holder **22**.

[0085] Referring to FIG. **18**, the sleeve **211** of the first holder **21** may include an insertion groove **211***c*. The insertion groove **211***c* may be formed in an outer surface of the body **211***a* of the sleeve **211**. The insertion groove **211***c* may be positioned opposite the protrusion **211***b* of the sleeve **211**. For example, the protrusions **211***b* and insertion grooves **211***c* may be formed by pressing a portion of the body **211***a* toward the pin **30**P.

[0086] A guide protrusion **11***t* may protrude from an inner surface of the slot **11***b* of the first side core **11** toward the insertion groove **211***c*, and may be inserted into the insertion groove **211***c*. The guide protrusions **11***t* may have a shape corresponding to the insertion grooves **211***c*, and a distal end of the guide protrusion **11***t* may be rounded.

[0087] Accordingly, the guide protrusion **11***t* and the insertion groove **211***c* may guide coupling of the slot **11***b* and the sleeve **211**.

[0088] An insertion protrusion **211***d* may protrude from one side of the body **211***a* facing the slit **11***c*, i.e., from the second short side SS**2**. The insertion protrusion **211***d* may be inserted into the slit **11***c* to block the slit **11***c*. Here, the width w**12** of the slit **11***c* may be smaller than a width w**3** of the pin **30**P. Accordingly, the sleeve **211** of the first holder **21** may cover the slit **11***c* of the first side core **11**.

[0089] Referring to FIG. **19**, an outer surface of the body **211***a* of the sleeve **211** may be flat without a groove, and an inner surface of the slot **11***b* of the first side core **11** may also be flat without a protrusion and may be parallel to the outer surface of the body **211***a*. That is, the insertion groove **211***c* and the guide protrusion **11***t* described above with reference to FIG. **18** may be omitted.

[0090] FIGS. **20** and **21** together with FIG. **1**, the housing **3** may have a hollow cylindrical shape. The housing **3** may surround an outer circumferential surface of the core **10** of the stator **1**. The diameter of the middle core **13** may be equal to the diameters of the first and second side cores **11** and **12** (see FIGS. **12** and **13**). An annular channel **3***c* may be recessed from an inner circumferential surface of the housing **3** and may extend in a circumferential direction of the housing **3**. A portion of the inner circumferential surface of the housing **3** that is located outside the channel **3***c* may contact the first and second side cores **11** and **12**. The channel **3***c* may face the middle core **13** of the core **10**, and the holes **13***c* of the middle core **13** may be formed along the channel **3***c*. A port **3***a* may be formed in the housing **3**, and an oil inlet **3***b* connected to the channel **3***c* may be formed in the port **3***a*.

[0091] Accordingly, oil introduced through the oil inlet **3***b* may be supplied to the holes **13***c* of the middle core **13** through the channel **3***c*.

[0092] Referring to FIG. **22** together with FIG. **1**, a diameter D**3** of the middle core **13** may be smaller than diameters D**1** and D**2** of the first and second side cores **11** and **12**. The middle core **13** may be stepped downward from the first and second side cores **11** and **12**. The middle core **13** may form the bottom of the annular channel **13***g* formed in the outer circumferential surface of the core **10** of the stator **1**, and the first and second side cores **11** and **12** may form side walls of the channel

13*g*. The holes **13***c* of the middle core **13** may be formed along the channel **13***g*.
[0093] The housing **3** may have a hollow cylindrical shape. The housing **3** may surround the outer circumferential surface of the core **10** of the stator **1**.
[0094] For example, the annular channel corresponding to the middle core **13** may not be formed in the inner circumferential surface of the housing **3**. In this case, the inner circumferential surface of the housing **3** may contact the first and second side cores **11** and **12**, and the channel **13***g* may be formed between the middle core **13** and the inner circumferential surface of the housing **3**.
[0095] In another example, the annular channel **3***c* (see FIG. **20**) corresponding to the middle core **13** may be formed in the inner circumferential surface of the housing **3**. In this case, a portion of the inner circumferential surface of the housing **3** that is located outside the channel **3***c* may contact the first and second side cores **11** and **12**, and the channels **13***g* and **3***c* may be disposed in parallel.
[0096] The port **3***a* may be formed in the housing **3**, and the oil inlet **3***b* connected to the channel **13***g* or the channels **13***g* and **3***c* may be formed in the port **3***a*.
[0097] Accordingly, oil introduced through the oil inlet **3***b* may be supplied to the holes **13***c* of the middle core **13** through the channel **13***g* or the channels **13***g* and **3***c*.
[0098] Referring to FIGS. **23** and **24**, the hole **13***c* of the middle core **13** may be formed through both sides of the middle core **13**. In the axial direction of the core **10**, the first and second side cores **11** and **12** may block the hole **13***c* of the middle core **13**.
[0099] The coils **30** may pass through the sleeve **211** inserted into the slot **11***b* of the core **11**, the slot **13***b* of the middle core **13**, and the sleeve **221** inserted into the slot **12***b* of the second side core **12**.
[0100] The oil introduced into the hole **13***c* of the middle core **13** may pass through the ribs **13***r* formed on the inner surface of the hole **13***c*. In this case, the ribs **13***r* are arranged in a zigzag, such that a path Pi of the oil Oi passing through the hole **13***c* may also be formed in a zigzag shape. Accordingly, the path Pi of the oil Oi passing through the hole **13***c* becomes longer, thereby increasing an area of contact between the oil Oi and the middle core **13**. In addition, cooling efficiency of a portion corresponding to the central portion of the coil **30** may be improved by the oil Oi.
[0101] The oil Oi having passed through the hole **13***c* may be supplied to the slot **13***b* of the middle core **13** on which the coil **30** is located. In this case, the gum **13***g* of the middle core **13** that forms the inner circumferential surface **13***aa* of the middle core **13** may form a portion of the path of the oil Oi in the slot **13***b*. The oil Oi may be distributed to the sleeve **211** inserted into the first side core **11** and the sleeve **221** inserted into the second side core **12**. In this case, the sleeve **211** may form a portion of the path of the oil Oi in the sleeve **211** by covering the slit **11***c* of the first side core **11**. In addition, the sleeve **221** may form a portion of the path of the oil Oi in the sleeve **221** by covering the slit **12***c* of the second side core **12**. Accordingly, the oil Oi introduced into the middle core **13** may flow along the internal spaces **211**S and **221**S of the sleeves **211** and **221** and may cool the core **10**.
[0102] Referring to FIGS. **25** and **26**, oil Oi introduced through the oil inlet **3***b* may be distributed from the channel **3***c* of the housing **3** to the holes **13***c* of the middle core **13**, and may cool the central portion of the core **10** and the central portion of the coil **30** that corresponds to the central portion of the core **10**. Subsequently, the oil Oi having passed through the holes **13***c* may pass through the internal spaces **211**S and **221**S of the sleeves **211** and **221** to be discharged outside the sleeves **211** and **221**. The discharged oil Oi may also flow to a portion of the coil **30** outside the sleeves **211** and **221**. That is, the oil Oi may directly cool the coil **30** from the center to both ends thereof (i.e., first and second end-turn portions **31** and **32**, see FIG. **14**). Accordingly, the coil **30** of the stator **1** may be smoothly cooled, and the performance of the electric motor M may be improved. Further, a compact structure for cooling the coil **30** of the stator **1** may be provided, which is effective in reducing the volume of the electric motor M, as well as in reducing the manufacturing cost of the electric motor M.

[0103] The discharged oil Oi may be collected and provided back to the oil inlet **3***b*. The electric motor M or a device including the same may include a means for circulating the oil Oi (e.g., pump). The electric motor M or a device including the same may include a means for cooling the discharge oil Oi (e.g., air cooling device and/or water cooling device).
[0104] Referring to FIGS. **1** to **26**, an electric motor M may include: a housing **3**; a stator **1** positioned inside the housing **3**; and a rotor **2** positioned inside the stator **1**, wherein the stator **1** includes: a core **10** having a hollow cylindrical shape, the core including a slot **10**S formed by penetrating both ends of the core **10** in an axial direction of the core **10**; a coil **30** wound around the slot **10**S and through which a current flows; and a sleeve **211** extending along the slot **10**S and covering a lateral surface of the coil, the sleeve **211** forming a path **211**P between the sleeve **211** and the coil **30**, wherein the core **10** may include a hole **13***c* communicating with the path **211**P of the sleeve **211**, and formed from an outer circumferential surface of the core **10** toward the slot **10**S, and the housing **3** may include an oil inlet **3***b* formed at the housing **3**.
[0105] The oil inlet **3***b* may provide oil to the holes **13***c* of the core **10**.
[0106] The slot **10**S of the core **10** may include a plurality of slots **10**S spaced apart from each other in a circumferential direction of the core **10**, wherein the sleeve **211** may include a plurality of sleeves **211** positioned in the plurality of slots **10**S, and the coil **30** may include a plurality of coils **30** wound around the plurality of sleeves **211**.
[0107] The hole **13***c* of the core **10** may include a plurality of holes **13***c* spaced apart from each other in the circumferential direction of the core **10**, wherein each of the plurality of holes **13***c* may be connected to each of the plurality of slots **10**S.
[0108] The electric motor M may further include an annular channel **3***c*; **13***g* formed between the outer circumferential surface of the core **10** and an inner circumferential surface of the housing **3**, wherein the channel **3***c*; **13***g* may connect the oil inlet **3***b* of the housing **3** and the plurality of holes **13***c* of the core **10**.
[0109] The core **10** may include: a first side core **11** forming one end of the core **10**; a second side core **12** forming the other end of the core **10**; and a middle core **13** positioned between the first side core **11** and the second side core **12**, wherein the hole **13***c* of the core **10** may be formed at the middle core **13**.
[0110] The slot **10**S of the core **10** may include: a first slot **11***b* formed at the first side core **11**; a second slot **12***b* formed at the second side core **12**; and a third slot **13***b* formed at the middle core **13**, wherein the sleeve may include: a first sleeve **211** positioned in the first slot **11***b*; and a second sleeve **221** positioned in the second slot **12***b* and opposite the first sleeve **211** with respect to the third slot **13***b*, wherein the hole **13***c* of the core **10** may be connected to the third slot **13***b*.
[0111] The sleeve **211** may include a non-conductive material.
[0112] The sleeve **211** may include a plastic material, and may be coupled to the core **10** by insert injection molding.
[0113] The slot **10**S of the core **10** may be formed from an inner circumferential surface of the core **10** in one direction intersecting the inner circumferential surface of the core **10**, wherein the coil **30** may include a plurality of coils **30** sequentially arranged in the one direction, wherein the sleeve **211** may include: a body **211***a* covering the plurality of coils **30**; and protrusions **211***b* protruding from the body **211***a* toward the plurality of coils **30**, wherein the path **211**P of the sleeve **211** may be formed between the protrusions **211***b* of the sleeve **211**.
[0114] Each of the plurality of coils **30** may have a rectangular cross-section, and the protrusions **211***b* of the sleeve **211** may contact four corners of each of the plurality of coils **30**.
[0115] A distal end of the protrusion **211***b* of the sleeve **211** may be rounded.
[0116] The body **211***a* of the sleeve **211** may include an outer surface at which an insertion groove **211***c* is formed, or an outer surface that is flat, wherein the slot **10**S of the core **10** may include an inner surface from which a guide protrusion **11***t* inserted into the insertion groove **211***c* protrudes, or an inner surface that is parallel to the flat outer surface of the body **211***a*.

[0117] The electric motor M may further include a holder **20** including the sleeve **211**, wherein the sleeve **211** may include a plurality of sleeves **211** spaced apart from each other in a circumferential direction of the core **10**, wherein the holder **20** may include: a first ring **210** positioned on one end of the core **10**, and connecting the plurality of sleeves **211**; and a plurality of first protruding portions **212** protruding in a direction opposite the plurality of sleeves **211**, and staggered with the plurality of sleeves **211**, wherein the coil **30** may include: a first portion **30**Pa positioned inside the sleeve **211**; and a second portion positioned outside the sleeve **211**, bent from one end of the first portion **30**Pa of the coil **30**, and positioned on the first protruding portion **212**.
[0118] The holder **20** may include: a second ring **220** opposite the first ring **210** with respect to the core **10**; and second protruding portions **222** protruding in a direction opposite the plurality of first protruding portions **211**, and staggered with the plurality of sleeves **211**, wherein the coil **30** may include a third portion **30**Pb positioned outside the sleeve **211**, bent from another end of the first portion **30**P of the coil **30**, and positioned on the second protruding portion **222**.
[0119] The plurality of first protruding portions **212** may have a corrugated shape on the first ring **210**, and the coil **30** may be one of the plurality of coils **30** wound around the plurality of sleeves **211**.
[0120] The electric motor according to the present disclosure has the following effects.
[0121] According to at least one of the embodiments of the present disclosure, an electric motor with improved cooling performance may be provided.
[0122] According to at least one of the embodiments of the present disclosure, a structure for directly cooling a stator coil with oil may be provided.
[0123] According to at least one of the embodiments of the present disclosure, a structure for directly cooling a coil from the center to both ends thereof with oil may be provided.
[0124] According to at least one of the embodiments of the present disclosure, a structure of a core of a stator that provides a path of oil may be provided.
[0125] According to at least one of the embodiments of the present disclosure, a holder for providing a path of oil that directly cools a coil may be provided.
[0126] According to at least one of the embodiments of the present disclosure, a holder for fixing the position of a coil while providing electrical isolation between the coil and a core of a stator may be provided.
[0127] According to at least one of the embodiments of the present disclosure, a structure for increasing cooling efficiency of a stator by forming a zigzag path of oil at the center of a core may be provided.
[0128] According to at least one of the embodiments of the present disclosure, a structure for fixing an end-turn portion of a coil may be provided.
[0129] According to at least one of the embodiments of the present disclosure, a structure for reducing the volume of an electric motor and the manufacturing cost of the electric motor may be provided.
[0130] Certain embodiments or other embodiments of the disclosure described above are not mutually exclusive or distinct from each other. Any or all elements of the embodiments of the disclosure described above may be combined or combined with each other in configuration or function.
[0131] For example, a configuration “A” described in one embodiment of the disclosure and the drawings and a configuration “B” described in another embodiment of the disclosure and the drawings may be combined with each other. Namely, although the combination between the configurations is not directly described, the combination is possible except in the case where it is described that the combination is impossible.
[0132] The foregoing embodiments are merely examples and are not to be considered as limiting the present disclosure. The scope of the present disclosure should be determined by rational

interpretation of the appended claims, and all modifications within the equivalents of the disclosure are intended to be included within the scope of the present disclosure.

Claims

1. An electric motor comprising: a housing; a stator positioned inside the housing; and a rotor positioned inside the stator, wherein the stator comprises: a core having a hollow cylindrical shape, the core including a slot formed by penetrating both ends of the core in an axial direction of the core; a coil wound around the slot and through which a current flows; and a sleeve extending along the slot and covering a lateral surface of the coil, the sleeve forming a path between the sleeve and the coil, wherein the core comprises a hole formed from an outer circumferential surface of the core toward the slot, and communicating with the path of the sleeve, wherein the housing comprises an oil inlet formed at the housing.
2. The electric motor of claim 1, wherein the slot of the core comprises a plurality of slots spaced apart from each other in a circumferential direction of the core, wherein the sleeve comprises a plurality of sleeves positioned in the plurality of slots, wherein the coil comprises a plurality of coils wound around the plurality of sleeves.
3. The electric motor of claim 2, wherein the hole of the core comprises a plurality of holes spaced apart from each other in the circumferential direction of the core, wherein each of the plurality of holes is connected to each of the plurality of slots.
4. The electric motor of claim 3, further comprising an annular channel formed between the outer circumferential surface of the core and an inner circumferential surface of the housing, wherein the channel connects the oil inlet of the housing and the plurality of holes of the core.
5. The electric motor of claim 1, wherein the core comprises: a first side core forming one end of the core; a second side core forming the other end of the core; and a middle core positioned between the first side core and the second side core, wherein the hole of the core is formed at the middle core.
6. The electric motor of claim 5, wherein the slot of the core comprises: a first slot formed at the first side core; a second slot formed at the second side core; and a third slot formed at the middle core, wherein the sleeve comprises: a first sleeve positioned in the first slot; and a second sleeve positioned in the second slot and opposite the first sleeve with respect to the third slot, wherein the hole of the core is connected to the third slot.
7. The electric motor of claim 1, wherein the sleeve comprises a non-conductive material.
8. The electric motor of claim 7, wherein the sleeve comprises a plastic material, and is coupled to the core by insert injection molding.
9. The electric motor of claim 1, wherein the slot of the core is formed from an inner circumferential surface of the core in one direction intersecting the inner circumferential surface of the core, wherein the coil comprises a plurality of coils sequentially arranged in the one direction, wherein the sleeve comprises: a body covering the plurality of coils; and protrusions protruding from the body toward the plurality of coils, wherein the path of the sleeve is formed between the protrusions of the sleeve.
10. The electric motor of claim 9, wherein each of the plurality of coils has a rectangular cross-section, wherein the protrusions of the sleeve contact four corners of each of the plurality of coils.
11. The electric motor of claim 10, wherein a distal end of the protrusion of the sleeve is rounded.
12. The electric motor of claim 11, wherein the body of the sleeve comprises: an outer surface at which an insertion groove is formed; or an outer surface that is flat, wherein the slot of the core comprises: an inner surface from which a guide protrusion inserted into the insertion groove protrudes; or an inner surface that is parallel to the flat outer surface of the body.
13. The electric motor of claim 1, further comprising a holder including the sleeve, wherein the sleeve comprises a plurality of sleeves spaced apart from each other in a circumferential direction

of the core, wherein the holder comprises: a first ring positioned on one end of the core and connecting the plurality of sleeves; and a plurality of first protruding portions protruding in a direction opposite the plurality of sleeves, and staggered with the plurality of sleeves, wherein the coil comprises: a first portion positioned inside the sleeve; and a second portion positioned outside the sleeve, bent from one end of the first portion of the coil, and positioned on the first protruding portion.

14. The electric motor of claim 13, wherein the holder comprises: a second ring opposite the first ring with respect to the core; and second protruding portions protruding in a direction opposite the plurality of first protruding portions, and staggered with the plurality of sleeves, wherein the coil comprises a third portion positioned outside the sleeve, bent from another end of the first portion of the coil, and positioned on the second protruding portion.

15. The electric motor of claim 13, wherein the plurality of first protruding portions have a corrugated shape on the first ring, wherein the coil is one of the plurality of coils wound around the plurality of sleeves.