

DESCRIPTION

STATOR AND ELECTRIC MOTOR HAVING SAME

TECHNICAL FIELD

[0001] The present disclosure relates to a stator and an electric motor including the stator.

BACKGROUND ART

[0002] An electric motor including a stator in which a pair of insulators is attached above and below a stator core is known (see PTL 1, for example). Hereinafter, the stator will be described with reference to Figs. 13, 14A, and 14B.

[0003] Fig. 13 is an exploded perspective view illustrating a configuration of a conventional stator. Figs. 14A and 14B are sectional views illustrating states before and after attaching an insulator in the conventional stator. Here, Fig. 14A illustrates a state before the insulator is attached, and Fig. 14B illustrates a state after the insulator is attached.

[0004] As illustrated in Fig. 13, in conventional stator 100, a pair of insulators (insulator 101a, Insulator 101b) is attached in such a manner as to sandwich stator core 102 from above and below the stator core. The insulator includes a plurality of cylindrical walls extending in a direction orthogonal to a base having a flat portion and covering a wall surface of each slot. As illustrated in Figs. 14A and 14B, the conventional insulator is attached to stator core 102 such that a wall of upper insulator 101a and a wall of lower insulator 101b overlap each other inside slot 103. Electric insulation between a winding wire and the stator core is provided by winding the winding wire around the slot via the insulator. An electric motor including such a stator has a feature that the number of assembling steps can be reduced because the number of components is small.

Citation List

Patent Literature

[0005] PTL 1: Unexamined Japanese Patent Publication No. 2012-200116

SUMMARY OF THE INVENTION

[0006] The configuration of the conventional insulator has a structural problem derived from, in particular, attachment of the insulator, and there is room for improvement from

the viewpoint of improving electrical efficiency and assembly workability of the electric motor.

[0007] Specifically, in the configuration of the conventional stator, when the upper and lower walls of the insulator are overlapped inside the slot, a clearance for preventing contact between the upper and lower walls is provided. In this case, the slots are narrowed by the thickness of the upper and lower walls and the width of the clearance (dimension Y in Fig. 14B), and the slot space factor of the winding wire decreases. When the winding wire is wound, the distance between the winding wire and the stator core is increased by the thickness of the upper and lower walls and the width of the clearance, and thus the circumferential length of the winding wire becomes long, and the electric resistance of the winding wire increases, which may reduce the electric efficiency of the electric motor.

[0008] In addition, in the configuration of the conventional stator, when a wall of the insulator is inserted into the slot, tensile and compressive stresses are applied in a radial direction from the inner circumferential portion as a starting point, and deformation such as bending of the outer circumferential portion in the circumferential direction may occur. In this case, due to the deformation of the outer circumferential portion of the insulator at the time of attachment, the positional relationship between the wall and the slot is shifted, and it takes extra time and effort to fit them, which may become a bottleneck in reducing the number of work steps.

[0009] One of the objects of the present disclosure is to provide a stator that improves electric efficiency of an electric motor and improves workability in an insulator attachment step, and an electric motor including the stator.

[0010] A stator according to an aspect of the present disclosure includes a stator core having a substantially cylindrical shape, the stator core including a plurality of slots, a pair of insulators that sandwiches the stator core from both sides in an axial direction in the substantially cylindrical shape, and a winding wire wound in an annular shape around the stator core via the insulators, wherein the insulators include a base including a flat portion orthogonal to the axial direction, the base being in contact with an end of the substantially cylindrical shape of the stator core in the axial direction, a plurality of walls extending in the axial direction from the base along an inner wall of the slot, and a slot cell having a substantially cylindrical shape attached to an inner circumference of the wall.

[0011] The present disclosure can provide, by approaching to the insulator, a stator that improves electric efficiency of an electric motor and improves workability in an insulator

attachment step, and an electric motor including the stator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Fig. 1 is a side view illustrating a ceiling fan on which an electric motor according to an exemplary embodiment of the present disclosure is mounted.

Fig. 2 is a sectional view illustrating the electric motor according to the exemplary embodiment of the present disclosure.

Fig. 3 is a plan view illustrating a partial section of a stator according to the exemplary embodiment of the present disclosure.

Fig. 4 is an exploded perspective view illustrating a configuration of the stator according to the exemplary embodiment of the present disclosure.

Fig. 5A is a perspective view illustrating a first insulator of the stator according to the exemplary embodiment of the present disclosure.

Fig. 5B is a perspective view illustrating the first insulator of the stator according to the exemplary embodiment of the present disclosure.

Fig. 6A is a perspective view illustrating a second insulator of the stator according to the exemplary embodiment of the present disclosure.

Fig. 6B is a perspective view illustrating the second insulator of the stator according to the exemplary embodiment of the present disclosure.

Fig. 7A is a diagram illustrating an assembly procedure of the stator according to the exemplary embodiment of the present disclosure.

Fig. 7B is a diagram illustrating an assembly procedure of the stator according to the exemplary embodiment of the present disclosure.

Fig. 7C is a diagram illustrating an assembly procedure of the stator according to the exemplary embodiment of the present disclosure.

Fig. 7D is a diagram illustrating an assembly procedure of the stator according to the exemplary embodiment of the present disclosure.

Fig. 8A is a sectional view illustrating a longitudinal section of the stator according to the exemplary embodiment of the present disclosure.

Fig. 8B is a sectional view illustrating a longitudinal section of the stator according to the exemplary embodiment of the present disclosure.

Fig. 8C is a sectional view illustrating a longitudinal section of the stator according to the exemplary embodiment of the present disclosure.

Fig. 8D is a sectional view illustrating a longitudinal section of the stator according to the exemplary embodiment of the present disclosure.

Fig. 9 is a sectional view illustrating a transverse section taken along line A-A illustrated in Fig. 2 of the stator according to the exemplary embodiment of the present disclosure.

Fig. 10 is a sectional view illustrating a longitudinal section taken along line E-E illustrated in Fig. 3 of the stator according to the exemplary embodiment of the present disclosure.

Fig. 11A is an enlarged perspective view illustrating a main part of the first insulator of the stator according to the exemplary example of the present disclosure.

Fig. 11B is an enlarged perspective view illustrating a main part of the first insulator of the stator according to the exemplary example of the present disclosure.

Fig. 12A is an enlarged perspective view illustrating a main part of the second insulator of the stator according to the exemplary example of the present disclosure.

Fig. 12B is an enlarged perspective view illustrating a main part of the second insulator of the stator according to the exemplary example of the present disclosure.

Fig. 13 is an exploded perspective view illustrating a configuration of a conventional stator.

Fig. 14A is a sectional view illustrating states before and after attaching an insulator in a conventional stator.

Fig. 14B is a sectional view illustrating states before and after attaching the insulator in the conventional stator.

DESCRIPTION OF EMBODIMENT

[0013] Hereinafter, an exemplary embodiment of the present disclosure will be described with reference to the accompanying drawings. Same symbols are assigned to same or equivalent components and members illustrated in the exemplary embodiment and a modified example. Explanation for the same or equivalent components and members will not be repeated as appropriate. Dimensions of members in the drawings are appropriately enlarged or reduced to facilitate understanding. In each of the drawings, some of members not important for describing the exemplary embodiment are omitted.

[0014] Terms including ordinal numbers such as first and second are used to describe various components, but the terms are used only for the purpose of distinguishing one

component from other components, and the components are not limited by the terms.

[0015] Electric motor 2 according to an exemplary embodiment of the present disclosure will be described with reference to the drawings. Fig. 1 is a side view illustrating ceiling fan 1 on which electric motor 2 according to the present exemplary embodiment is mounted. Fig. 2 illustrates a longitudinal section along a rotation axis of electric motor 2. The application of electric motor 2 is not limited, but as an example, electric motor 2 can be suitably mounted on a ceiling fan.

[0016] Ceiling fan 1 includes support column 4, shaft 6, blades 3, body cover 5, and electric motor 2.

[0017] Support column 4 is a hollow cylindrical member extending downward from the ceiling.

[0018] Shaft 6 is a vertically extending hollow shaft and is fixed to the lower end of support column 4.

[0019] Blade 3 has a substantially rectangular plate shape, and is provided on an outer circumference of electric motor 2.

[0020] Body cover 5 has a substantially hemispherical dome shape and covers the lower side of electric motor 2.

[0021] Electric motor 2 is an outer rotor-type alternating-current electric motor. Electric motor 2 includes operation capacitor 10, upper cover 11, rotor cover 12, bearing housings 13a, 13b, ball bearings 14a, 14b, rotor 19, and stator 20.

[0022] Operation capacitor 10 supplies an AC voltage to electric motor 2. Operation capacitor 10 is provided on a side surface of shaft 6.

[0023] Upper cover 11 covers rotor 19 and stator 20 from the upper side, and is fixed to the outer circumferential side of rotor 19.

[0024] Rotor cover 12 covers stator 20 from the lower side and is fixed to the lower side of rotor 19.

[0025] Bearing housing 13a is a recess formed in rotor cover 12 and supports the outer ring of ball bearing 14a. Bearing housing 13b is a recess formed in upper cover 11 and supports the outer ring of ball bearing 14b.

[0026] The inner ring of ball bearing 14a and the inner ring of ball bearing 14b are fixed to shaft 6. In ball bearing 14a and ball bearing 14b according to the present exemplary embodiment, each of the inner rings is a fixed wheel, and the outer ring is a rotating wheel.

[0027] Rotor 19 has a substantially hollow cylindrical shape and is disposed on the outer

circumferential side of stator 20. Rotor 19 rotates around stator 20 integrally with blades 3 at the time of power supply. Rotor 19 includes rotor core 17.

[0028] Rotor core 17 is a metal member rotatably provided facing a side surface of stator core 16. Rotor core 17 includes end ring 15.

[0029] End ring 15 is an annular member provided above and below rotor core 17 sandwiching the rotor core.

[0030] Stator 20 is disposed on the inner circumference of rotor 19 and is fixed by shaft 6. Stator 20 includes stator core 16, insulator 7, A-phase winding wire 8, and B-phase winding wire 9.

[0031] Stator core 16 is formed in a substantially cylindrical shape by stacking magnetic steel plates while pressing. Stator core 16 includes center hole 21.

[0032] Center hole 21 is a circular hole for inserting shaft 6 into stator core 16, and is provided at the center of stator core 16.

[0033] Insulator 7 covers a part of the upper surface and a part of the lower surface of stator core 16 to ensure insulation of winding wires. Insulator 7 has a substantially hollow disk shape. Insulator 7 includes first insulator 30 and second insulator 40. Details of first insulator 30 and second insulator 40 will be described later.

[0034] A-phase winding wire 8 is applied in a plurality of first slots 24 to be described later, and B-phase winding wire 9 is applied in a plurality of second slots 25 to be described later, and they are thus wound around stator core 16 via insulator 7. The AC voltage advanced by operation capacitor 10 is supplied to one of A-phase winding wire 8 and B-phase winding wire 9, and the AC voltage before phase advancement is supplied to the other. As a result, A-phase winding wire 8 and B-phase winding wire 9 generate a rotating magnetic field around stator 20, and generate a rotating torque in rotor 19 by the principle of an induction motor.

[0035] With such a configuration, at the time of power supply, shaft 6 and stator 20 remain still, and upper cover 11, rotor cover 12, and rotor 19 rotate.

[0036] Next, stator 20 will be described with reference to Figs. 3 and 4. Fig. 3 is a plan view illustrating a partial section of stator 20. In this drawing, stator core 16 is illustrated in the upper-left quarter, a state where first insulator 30 and second insulator 40 are attached is illustrated in the lower-left quarter, and a state where A-phase winding wire 8 and B-phase winding wire 9 are applied is illustrated in the right half. Fig. 4 is an exploded perspective view illustrating a configuration of stator 20. Hereinafter, a direction parallel to

a side surface of the substantially cylindrical shape of stator core 16 (a direction parallel to the rotation axis of electric motor 2) is referred to as an “axial direction”, a direction orthogonal to the axial direction is referred to as a “radial direction”, a direction away from center hole 21 in the radial direction is referred to as “radially outward”, and a direction opposite to the direction of radially outward is referred to as “radially inward”. A section along a plane including a straight line parallel to the axial direction is referred to as a longitudinal section, and a section along a plane orthogonal to the axial direction is referred to as a transverse section.

[0037] As illustrated in Fig. 3, stator core 16 further includes first tooth 22, second tooth 23, first slot 24, second slot 25, first communication passage 26, and second communication passage 29.

[0038] First tooth 22 is a rod-shaped portion extending radially outward from the outer circumference of stator core 16. A plurality of (for example, 14) first teeth 22 are arranged at predetermined intervals on the outer circumferential side of stator core 16.

[0039] Second tooth 23 is a rod-shaped portion that is bifurcated from the outer circumferential portion of the first tooth 22 and extends radially outward. A plurality of (for example, 28) second teeth 23 are arranged at predetermined intervals on the outer circumferential portion of first tooth 22. Second tooth 23 includes extended part 55.

[0040] Extended part 55 forms an inner wall of second slot 25 together with second tooth 23. Extended part 55 is provided to extend from the extending tip end of second tooth 23 to the opposite side of first communication passage 26.

[0041] First slot 24 is an opening provided for applying A-phase winding wire 8, and is provided between the plurality of first teeth 22. A plurality of first slots 24 are formed with the side surfaces of first teeth 22 as an inner wall. First slot 24 includes first slot opening 56.

[0042] First slot opening 56 is an opening extending radially outward from first slot 24, and is provided in a substantially rectangular shape on the inner wall of first slot 24.

[0043] Second slot 25 is an opening provided for applying B-phase winding wire 9, and is provided between the plurality of second teeth 23. A plurality of second slots 25 are formed with the side surfaces of the second teeth 23 and extended part 55 as an inner wall. The second slot is provided with second slot opening 57.

[0044] Second slot opening 57 is an opening extending radially outward from second slot 25, and is provided in a substantially rectangular shape on the inner wall of second slot 25.

[0045] First communication passage 26 is a passage space that extends radially outward from each first slot opening 56 and communicates with a substantially cylindrical side surface of stator core 16, and is formed between two second teeth 23 adjacent to each other. First communication passage 26 includes first opening 27.

[0046] First opening 27 is a substantially rectangular opening formed at an end on the radially outer side of first communication passage 26. In other words, first opening 27 is formed in a substantially rectangular shape on a side surface of the substantially cylindrical shape of stator core 16.

[0047] Second communication passage 29 is a passage space extending radially outward from each second slot opening 57 and communicating with a substantially cylindrical side surface of stator core 16, and is formed between extended parts 55. Second communication passage 29 includes second opening 28.

[0048] Second opening 28 is a substantially rectangular opening formed at an end on the radially outer side of second communication passage 29. In other words, second communication passage 29 is formed in a substantially rectangular shape on the side surface of the substantially cylindrical shape of stator core 16.

[0049] First communication passage 26 and second communication passage 29 can be used as a passage of a wire when a winding wire is applied. Thus, as illustrated in Fig. 3, A-phase winding wire 8 is applied in each first slot 24 through first communication passage 26, and is wound around each first tooth 22 via first insulator 30 and first slot cell 51 described later. B-phase winding wire 9 is applied in each second slot 25 through second communication passage 29, and is wound around each second tooth 23 via second insulator 40 and second slot cell 53 described later.

[0050] As illustrated in Fig. 4, insulator 7 according to the present exemplary embodiment includes a total of four pieces divided into two in the radial direction and divided into two in the up-down directions. That is, insulator 7 includes a pair of first insulators 30 that sandwich the plurality of first teeth 22 from both sides in the axial direction, and a pair of second insulators 40 that sandwich the plurality of second teeth 23 from both sides in the axial direction.

[0051] First insulator 30 is formed in an annular shape and mainly covers first tooth 22 on the radially inner side of second insulator 40. First insulator 30 includes first base 31 and first wall 32.

[0052] First base 31 is an annular portion including a flat portion orthogonal to the axial

direction. First base 31 is provided in contact with the axial end surface of stator core 16 and is formed to cover each first tooth 22.

[0053] First wall 32 is a cylindrical portion extending in the axial direction from first base 31. First wall 32 is provided along the wall surface of first slot 24 and is formed in an annular shape having a substantially O shape in a plan view. First wall 32 is provided such that the height from first base 31 is equal to or less than half of the height of stator core 16 in the axial direction. First wall 32 includes first insulator opening 58.

[0054] First insulator opening 58 is a substantially rectangular opening provided on the radially outer side of first wall 32. First insulator opening 58 is provided at a position corresponding to first slot opening 56 when first insulator 30 is attached, and has the equivalent size as first slot opening 56.

[0055] Second insulator 40 is formed in an annular shape having a diameter larger than that of first insulator 30, and mainly covers second tooth 23 on the radially outer side of first insulator 30. Second insulator 40 includes second base 41 and second wall 42.

[0056] Second base 41 is an annular portion including a flat portion orthogonal to the axial direction. Second base 41 is provided in contact with the axial end surface of stator core 16 and is formed to cover second tooth 23.

[0057] Second wall 42 is a cylindrical portion extending in the axial direction from second base 41. Second wall 42 is provided along the wall surface of second slot 25 and is formed in an annular shape having a substantially O shape in a plan view. Second wall 42 is provided such that the height from first base 31 is equal to or less than half of the height of stator core 16 in the axial direction. Second wall 42 includes second insulator opening 59.

[0058] Second insulator opening 59 is a substantially rectangular opening provided on the radially outer side of second wall 42. Second insulator opening 59 is provided at a position corresponding to second slot opening 57 when second insulator 40 is attached, and has the equivalent size as second slot opening 57.

[0059] In this manner, by forming each of first insulator 30 and second insulator 40 independently in an annular shape, it is possible to reduce the influence of deformation of the outer circumferential portion in the circumferential direction even when tensile and compressive stress are applied in the radial direction from the inner circumferential portion as a starting point when the first insulator and the second insulator are attached to stator core 16. Thus, the insertion of second wall 42 into second slot 25 becomes easy, and the

attachment workability of the insulator improves.

[0060] As illustrated in Fig. 4, stator 20 further includes first slot cell 51, first slot wedge 52, second slot cell 53, and second slot wedge 54.

[0061] First slot cell 51 is a substantially cylindrical member that is attached to the inner circumference of first wall 32 after first insulator 30 is attached. The height of first slot cell 51 in the axial direction is equal to or less than the height of stator core 16 in the axial direction. That is, the height of first slot cell 51 in the axial direction is equal to or less than the thickness of stator core 16. First slot cell 51 includes first slot cell opening 60.

[0062] First slot cell opening 60 is a substantially rectangular opening provided on the radially outer side of first slot cell 51. First slot cell opening 60 is provided at a position corresponding to first insulator opening 58 when first slot cell 51 is attached to the inner circumference of first wall 32, and has the equivalent size as first insulator opening 58.

[0063] First slot wedge 52 is a substantially plate-like member attached so as to cover the outlet of first slot 24 to first communication passage 26 after A-phase winding wire 8 is applied. The height of first slot wedge 52 in the axial direction is equal to or larger than the distance between one first base 31 and the other first base 31 of the pair of first insulators 30.

[0064] First slot cell 51 and first slot wedge 52 are made of an insulating sheet such as a polyethylene terephthalate (PET) film, and are thinner than first wall 32. In the present exemplary embodiment, while the thickness of first wall 32 is about 0.3 mm to 0.5 mm, the thickness of first slot cell 51 and first slot wedge 52 is about 0.10 mm to 0.25 mm.

[0065] Second slot cell 53 is a substantially cylindrical member that is attached to the inner circumference of second wall 42 after second insulator 40 is attached. The height of second slot cell 53 in the axial direction is equal to or less than the height of stator core 16 in the axial direction. That is, the height of second slot cell 53 in the axial direction is equal to or less than the thickness of stator core 16. Second slot cell 53 includes second slot cell opening 61.

[0066] Second slot cell opening 61 is a substantially rectangular opening provided on the radially outer side of second slot cell 53. Second slot cell opening 61 is provided at a position corresponding to second insulator opening 59 when second slot cell 53 is attached to the inner circumference of second wall 42, and has the equivalent size as second insulator opening 59.

[0067] Second slot wedge 54 is a substantially plate-like member attached so as to cover

the outlet of second slot 25 to second communication passage 29 after B-phase winding wire 9 is applied. The height of second slot wedge 54 in the axial direction is equal to or larger than the distance between one second base 41 and the other second base 41 of the pair of second insulators 40.

[0068] Second slot cell 53 and second slot wedge 54 are made of an insulating sheet such as a PET film, and are thinner than second wall 42. In the present exemplary embodiment, while the thickness of second wall 42 is about 0.3 mm to 0.5 mm, the thickness of second slot cell 53 and second slot wedge 54 is about 0.10 mm to 0.25 mm.

[0069] Next, first insulator 30 will be described with reference to Figs. 5A, 5B, 11A, and 11B. Figs. 5A and 5B are perspective views illustrating first insulator 30. Here, Fig. 5A is a diagram of first insulator 30 as viewed from stator core 16 side, and FIG. 5B is a diagram of first insulator 30 as viewed from the coil end side. Figs. 11A and 11B are enlarged perspective views illustrating main parts of Figs. 5A and 5B.

[0070] First insulator 30 further includes first joint 33, first inner circumferential wall 36, first catch A34, first catch B35, and first press part 37.

[0071] First joint 33 is a partial arc-shaped portion provided avoiding first communication passage 26 on the outer circumferential side of first base 31.

[0072] First inner circumferential wall 36 is a cylindrical portion extending in a direction away from stator core 16 in the axial direction from the inner circumferential end of first base 31, that is, in a direction opposite to first wall 32.

[0073] First catch A34 is on the same plane as first base 31, and is provided to extend from the radially outer side to the radially inner side. For example, first catch A34 is formed in a protruding shape at both ends of the opening corresponding to first insulator opening 58 of first wall 32. Here, first catch A means catch A provided on the first insulator. Catch A is also referred to as an outer-circumferential-side catch in the sense of belonging to the outer circumferential side of the insulator.

[0074] First catch B35 is on the same plane as first base 31, and is provided to extend from the radially inner side to the radially outer side. For example, first catch B35 is formed in a protruding shape on the side of first wall 32 opposite to first insulator opening 58. Here, first catch B means catch B provided on the first insulator. Catch B is also referred to as an inner-circumferential-side catch in the sense of belonging to the inner circumferential side of the insulator.

[0075] First catch A34 and first catch B35 abut on both ends of first slot cell 51 in the

axial direction when first slot cell 51 is attached to the inner circumference of first wall 32, thereby suppressing the axial movement of first slot cell 51.

[0076] First press part 37 is provided to protrude radially inward from both ends of the opening corresponding to first insulator opening 58 of first wall 32. First press part 37 is protruded, for example, by a length equivalent to that of first catch A34.

[0077] Next, second insulator 40 will be described with reference to Figs. 6A, 6B, 12A, and 12B. Figs. 6A and 6B are perspective views illustrating second insulator 40. Here, Fig. 6A is a diagram of second insulator 40 as viewed from stator core 16 side, and Fig. 6B is a diagram of second insulator 40 as viewed from the coil end side. Figs. 12A and 12B are enlarged perspective views illustrating main parts of Figs. 6A and 6B.

[0078] Second insulator 40 further includes second joint 43, second inner circumferential wall 46, second outer circumferential wall 47, protrusion 48, second catch A44, second catch B45, and second press part 50.

[0079] Second joint 43 is an annular portion provided on the inner circumferential side of second base 41. In the example of Figs. 6A and 6B, second joint 43 is on the same plane as second base 41, and has a shape in which each side of a band shape is combined to form a tetradecagon shape.

[0080] Second inner circumferential wall 46 is a cylindrical portion extending in a direction away from stator core 16 in the axial direction from the inner circumferential end of second base 41, that is, in a direction opposite to second wall 42.

[0081] Second outer circumferential wall 47 is a partial cylindrical portion extending in a direction away from stator core 16 in the axial direction from the outer circumferential portion of second base 41, that is, in a direction opposite to second wall 42. Second outer circumferential wall 47 restricts protrusion of B-phase winding wire 9 to the radially outer side.

[0082] A plurality of (for example, 14) protrusions 48 are provided at predetermined intervals in the circumferential direction corresponding to respective first communication passages 26. Protrusion 48 extends in the axial direction from second base 41 along the wall surface of first communication passage 26 on the radially inner side of first opening 27. Protrusion 48 fits into first communication passage 26 and functions as a positioning member of second insulator 40 with respect to stator core 16. Protrusion 48 facilitates alignment between stator core 16 and second insulator 40, and improves assembly workability.

[0083] Extending distance h48 of protrusion 48 from second base 41 is larger than extending distance h42 of second wall 42 from second base 41. In this case, when second insulator 40 is attached, since protrusion 48 having a large extension distance (large height) from second base 41 is guided inward from first opening 27 first, stator core 16 and second insulator 40 are aligned, and second wall 42 can be easily put on stator core 16. As a result, assembly workability improves.

[0084] Second catch A44 is on the same plane as second base 41, and is provided to extend from the radially outer side to the radially inner side. For example, second catch A44 is formed in a protruding shape at both ends of the opening corresponding to second insulator opening 59 of second wall 42. Here, second catch A means catch A provided on the second insulator. Catch A is also referred to as an outer-circumferential-side catch in the sense of belonging to the outer circumferential side of the insulator.

[0085] Second catch B45 is on the same plane as second base 41, and is provided to extend from the radially inner side to the radially outer side. For example, second catch B45 is formed in a protruding shape on the side of second wall 42 opposite to second insulator opening 59. Here, second catch B means catch B provided on the second insulator. Catch B is also referred to as an inner-circumferential-side catch in the sense of belonging to the inner circumferential side of the insulator.

[0086] Second catch A44 and second catch B45 abut on both ends of second slot cell 53 in the axial direction when second slot cell 53 is attached to the inner circumference of second wall 42, thereby suppressing the axial movement of second slot cell 53.

[0087] Second press part 50 is provided to protrude radially inward from both ends of the opening corresponding to second insulator opening 59 of second wall 42. Second press part 50 is protruded, for example, by a length equivalent to that of second catch A44.

[0088] Next, an assembly procedure of stator 20 will be described with reference to Figs. 7A to 7D. Figs. 7A to 7D are diagrams illustrating an assembly procedure of stator 20.

[0089] (1) First, attach two first insulators 30 to stator core 16 from above and below, and then attach first slot cell 51 (Fig. 7A). For first insulator 30, insert first wall 32 along inner wall of first slot 24, and bring first base 31 and the axial end portion of stator core 16 into contact with each other. At this time, since the height of first wall 32 from first base 31 is equal to or less than half of the height of stator core 16 in the axial direction, it is possible to prevent collision between first wall 32 inserted from one end of first slot 24 and first wall 32 inserted from the other end. First slot cell 51 is attached on the inner circumference

of first wall 32, and axial movement of first wall 32 on the inner circumference is suppressed by bringing both axial ends into contact with first catch A34 and first catch B35 of first wall 32. Further, in first slot cell 51, first press part 37 of first insulator 30 is sandwiched between both ends of the opening corresponding to first slot cell opening 60, whereby the movement in the circumferential direction on the inner circumference of first wall 32 is suppressed.

[0090] (2) Next, wind A-phase winding wire 8 with a winding machine, and then attach first slot wedge 52 (Fig. 7B). First slot wedge 52 is provided between first slot cell 51 and A-phase winding wire 8 at a position facing first slot cell opening 60.

[0091] (3) Next, attach two second insulators 40 to stator core 16 from above and below, and then attach second slot cell 53 (Fig. 7C). In second insulator 40, insert second wall 42 along inner wall of second slot 25, and bring second base 41 and the axial end portion of stator core 16 into contact with each other. At this time, since the height of second wall 42 from second base 41 is equal to or less than half of the height of stator core 16 in the axial direction, it is possible to prevent collision between second wall 42 inserted from one end of the second slot 25 and second wall 42 inserted from the other end. Second slot cell 53 is attached on the inner circumference of second wall 42, and axial movement of second wall 42 in the axial direction is suppressed by bringing both ends in the axial direction into contact with second catch A44 and second catch B45 of second wall 42. Further, in second slot cell 53, second press part 50 of second insulator 40 is sandwiched between both ends of the opening corresponding to second slot cell opening 61, whereby the movement in the circumferential direction on the inner circumference of second wall 42 is suppressed.

[0092] (4) Next, wind B-phase winding wire 9 with a winding machine, and then attach second slot wedge 54 (Fig. 7D). Second slot wedge 54 is provided between second slot cell 53 and B-phase winding wire 9 at a position facing second slot cell opening 61. Thereafter, stator 20 is completed through an additional step such as a wire tip end process of the winding wire.

[0093] Next, a section of stator 20 will be described with reference to Figs. 8A to 8D. Fig. 8A illustrates a longitudinal section taken along line B-B in Fig. 3, Fig. 8B illustrates a longitudinal section taken along line C-C in Fig. 3, Fig. 8C illustrates a longitudinal section taken along line D-D in Fig. 3, and Fig. 8D illustrates a longitudinal section taken along line F-F in Fig. 3.

[0094] As illustrated in Figs. 8A and 8C, first catch B35 and first catch A34 extend in the

radial direction to hold first slot cell 51. First slot wedge 52 is interposed on the outer circumferential side of A-phase winding wire 8 to restrict protrusion of A-phase winding wire 8 to the outer circumferential side. First inner circumferential wall 36 extends in the axial direction on the inner circumferential side of A-phase winding wire 8 and prevents winding collapse of A-phase winding wire 8 toward the inner circumferential side. Second outer circumferential wall 47 extends in the axial direction on the outer circumferential side of B-phase winding wire 9 and prevents winding collapse of B-phase winding wire 9 toward the outer circumferential side. Second inner circumferential wall 46 extends in the axial direction on the inner circumferential side of B-phase winding wire 9 and prevents winding collapse of B-phase winding wire 9 toward the inner circumferential side.

[0095] As illustrated in Figs. 8B and 8D, second catch B45 and second catch A44 extend in the radial direction to hold second slot cell 53. First joint 33 and second joint 43 overlap each other in the axial direction on the end surface of stator core 16. In this example, second joint 43 is on top of first joint 33.

[0096] As illustrated in Fig. 8C, first slot cell 51 and first slot wedge 52 partially overlap each other, thereby securing an insulation distance (creepage distance). Second inner circumferential wall 46 extends between A-phase winding wire 8 and B-phase winding wire 9 to prevent contact therebetween.

[0097] Next, a section of stator 20 will be further described with reference to Figs. 9 and 10. Fig. 9 is a transverse sectional view taken along line A-A in Fig. 2. Fig. 10 is a longitudinal sectional view taken along line E-E in Fig. 3.

[0098] As illustrated in Fig. 9, first slot wedge 52 is inserted between A-phase winding wire 8 and the radially outer circumferential end of first slot cell 51. In other words, first slot wedge 52 is provided at a position facing first slot cell opening 60. This makes it possible to secure a creepage distance between A-phase winding wire 8 and stator core 16. The end of first slot cell 51 and the end of first slot wedge 52 overlap each other. First slot wedge 52 is pressed radially inward by first press part 37. In other words, first press part 37 presses first slot wedge 52 against A-phase winding wire 8 to hold first slot wedge 52.

[0099] Second slot wedge 54 is inserted between B-phase winding wire 9 and the radially outer circumferential end of second slot cell 53. In other words, second slot wedge 54 is provided at a position facing second slot cell opening 61. This makes it possible to secure a creepage distance between B-phase winding wire 9 and stator core 16. The end of second slot cell 53 and the end of second slot wedge 54 overlap each other. Second slot wedge 54

is pressed radially inward by second press part 50. In other words, second press part 50 presses second slot wedge 54 against B-phase winding wire 9 to hold second slot wedge 54.

[0100] First slot cell 51 is disposed between one first press part 37 and the other first press part 37 along first wall 32 in the circumferential direction of first slot 24. The movement of first slot cell 51 is suppressed in the circumferential direction on the inner circumference of first slot 24 by first press part 37. As a result, since first slot cell 51 does not obstruct the passage of the wire when A-phase winding wire 8 is applied, the winding work is smoothly performed.

[0101] Second slot cell 53 is disposed between one second press part 50 and the other second press part 50 along second wall 42 in the circumferential direction of second slot 25. The movement of second slot cell 53 is suppressed in the circumferential direction on the inner circumference of second slot 25 by second press part 50. As a result, since second slot cell 53 does not obstruct the passage of the wire when B-phase winding wire 9 is applied, the winding work is smoothly performed.

[0102] First catch A34, first catch B35, second catch A44, second catch B45, first press part 37, and second press part 50 (hereinafter, collectively referred to as “specific protrusions”) are provided at positions that do not interfere with A-phase winding wire 8 and B-phase winding wire 9. The winding wire that has been wound in an annular shape is protruded to the outermost side at the upper and lower center portions, and rounded corner R62 is formed at each corner. Thus, interference with the winding wire can be avoided by providing the specific protrusion in the vicinity of the corner while avoiding the vertical center portion of the winding wire. Corner R62 provided at each corner is also referred to as a corner portion.

[0103] In the conventional technology, as illustrated in Figs. 13, 14A, and 14B, the slot is narrowed by the thickness of the upper and lower walls and the width of the clearance (dimension Y in Fig. 14B), and the slot space factor of the winding wire is reduced.

[0104] In the present exemplary embodiment, as illustrated in Fig. 10, since first wall 32 of first insulator 30 is inserted along the inner wall of first slot 24 in both the upper and lower directions, a useless gap is hardly formed between stator core 16 and first wall 32 of first insulator 30. In addition, since the thickness of first slot cell 51 is thinner than the thickness of first wall 32, the total thickness (dimension X) of first wall 32 and first slot cell 51 is smaller than dimension Y in Fig. 14B. Second slot 25 has the same configuration,

second wall 42 of second insulator 40 is inserted along the inner wall of second slot 25 in both the upper and lower directions, and the thickness of second slot cell 53 is thinner than the thickness of second wall 42. With such a configuration, the stator of the present disclosure has a wider slot than ever before, and the slot space factor of the winding wire can be improved. In addition, in the stator of the present disclosure, since the circumferential length of the winding wire is shorter than ever before, the electrical resistance of the winding wire can be reduced, and the electrical efficiency of the electric motor can be improved while ensuring the insulation distance. Further, since the circumferential length of the winding wire is shorter than before, it is also possible to reduce the thickness of the electric motor.

[0105] The present disclosure has been described above based on the exemplary embodiment. It is to be understood by those skilled in the art that this exemplary embodiment is an example, that various modified examples in combinations of the components or the processing processes of the exemplary embodiment are possible, and that such modified examples fall within the scope of the present disclosure.

[0106] [Modified example]

A modified example will be described below. In the drawings and description of the modified example, the same or equivalent components and members as those in the exemplary embodiment are denoted by the same reference marks. The description overlapping with that of the exemplary embodiment will be omitted as appropriate, and the configuration different from the first exemplary embodiment will be mainly described.

[0107] In the description of the exemplary embodiment, an example has been described in which the pair of insulators has the same shape, but the upper and lower insulators may have different shapes.

[0108] Any combination of the above-described components is also effective as an aspect of a technical idea obtained by abstracting the exemplary embodiment and the modified example. For example, any explanatory matters of other exemplary embodiments may be combined with the exemplary embodiment, or any explanatory matters of the exemplary embodiment and other modified examples may be combined with the modified example.

[0109] The exemplary embodiment and the modified example have been described above. In understanding the technical idea obtained by abstracting the exemplary embodiment and the modified example, the technical idea should not be interpreted limited to the contents of the exemplary embodiment and the modified example. The above-

described exemplary embodiment and modified example are only specific examples, and many design changes such as changes, additions, and deletions of components can be made. In the exemplary embodiment, the contents capable of such a design change are emphasized with the notation “exemplary embodiment”. However, design changes are allowed even with contents without such notations.

INDUSTRIAL APPLICABILITY

[0110] The electric motor according to the present disclosure can be applied to, for example, a driving electric motor such as a ceiling fan.

REFERENCE MARKS IN THE DRAWINGS

[0111] 1: ceiling fan
2: electric motor
3: blade
4: support column
5: body cover
6: shaft
7: insulator
8: A-phase winding wire
9: B-phase winding wire
10: operation capacitor
11: upper cover
12: rotor cover
13a, 13b: bearing housing
14a, 14b: ball bearing
15: end ring
16: stator core
17: rotor core
19: rotor
20: stator
21: center hole
22: first tooth
23: second tooth

24: first slot
25: second slot
26: first communication passage
27: first opening
28: second opening
29: second communication passage
30: first insulator
31: first base
32: first wall
33: first joint
34: first catch A
35: first catch B
36: first inner circumferential wall
37: first press part
40: second insulator
41: second base
42: second wall
43: second joint
44: second catch A
45: second catch B
46: second inner circumferential wall
47: second outer circumferential wall
48: protrusion
50: second press part
51: first slot cell
52: first slot wedge
53: second slot cell
54: second slot wedge
55: extended part
56: first slot opening
57: second slot opening
58: first insulator opening
59: second insulator opening

60: first slot cell opening
61: second slot cell opening
62: corner R
100: stator
101a, 101b: insulator
102: stator core
103: slot

CLAIMS

1. A stator comprising:
 - a stator core having a substantially cylindrical shape, the stator core including a slot;
 - a pair of insulators that sandwiches the stator core from both sides in an axial direction in the substantially cylindrical shape; and
 - a winding wire wound in an annular shape around the stator core via the pair of insulators,wherein each of the pair of insulators includes:
 - a base including a flat portion orthogonal to the axial direction, the base being in contact with an end of the substantially cylindrical shape of the stator core in the axial direction;
 - a wall extending in the axial direction from the base along an inner wall of the slot; and
 - a slot cell having a substantially cylindrical shape attached to an inner circumference of the wall.
2. The stator according to Claim 1, wherein the slot cell has a thickness smaller than a thickness of the wall.
3. The stator according to Claim 1, wherein the wall has a height from the base equal to or less than a half of a thickness of the stator core.
4. The stator according to Claim 1, wherein the slot cell has a height in the axial direction equal to or less than a thickness of the stator core.
5. The stator according to Claim 1, wherein the wall includes:
 - an outer-circumferential-side catch provided on a same plane as the base and extending from an outer side in a radial direction in the substantially cylindrical shape toward an inner side in the radial direction; and
 - an inner-circumferential-side catch provided on the same plane as the

base and extending from the inner side in the radial direction toward the outer side in the radial direction, and

the slot cell is disposed between the outer-circumferential-side catch and the inner-circumferential-side catch provided on one insulator of the pair of insulators and the outer-circumferential-side catch and the inner-circumferential-side catch provided on the other insulator of the pair of insulators different from the one insulator, and a movement of the slot cell in the axial direction is suppressed by the outer-circumferential-side catch and the inner-circumferential-side catch provided in each of the one insulator and the other insulator.

6. The stator according to Claim 1, wherein

the stator core includes:

a slot opening opening outward in the radial direction in the substantially cylindrical shape from the slot; and

a communication passage communicating with a side surface of the stator core from the slot opening,

the wall includes an insulator opening corresponding to the slot opening, and

the slot cell includes:

a slot cell opening corresponding to the insulator opening; and

a slot wedge having a substantial plate shape provided between the slot cell and the winding wire at a position facing the slot cell opening.

7. The stator according to Claim 6, wherein the slot wedge has a height in the axial direction equal to or larger than an interval between the base provided on one insulator of the pair of insulators and the base provided on the other insulator of the pair of insulators different from the one insulator.

8. The stator according to Claim 6, wherein

the wall includes a press part that is protruded inward in the radial direction from both ends of an opening of the insulator opening and abuts on the slot wedge, and

the press part presses the slot wedge inward in the radial direction and presses the slot wedge against the winding wire to hold the slot wedge.

9. The stator according to Claim 6, wherein
the wall includes a press part protruding inward in the radial direction from both ends of an opening of the insulator opening and abutting on the slot wedge, and
in the slot cell, both ends of an opening of the slot cell opening sandwich the press part, and movement of the slot cell in a circumferential direction on an inner circumference of the slot is suppressed by the press part.

10. The stator according to Claim 5, wherein the winding wire includes a rounded corner portion near the outer-circumferential-side catch and the inner-circumferential-side catch in winding in the annular shape.

11. The stator according to Claim 8 or 9, wherein the winding wire includes a rounded corner portion near the press part in winding in the annular shape.

12. An electric motor comprising the stator according to Claim 1.

13. An electric motor comprising:
a stator core including a plurality of first teeth, a first slot formed between the plurality of first teeth, a plurality of second teeth extending from an inner side in a radial direction of each of the plurality of first teeth toward an outer side in the radial direction, and a second slot formed between the plurality of second teeth;
a pair of first insulators sandwiching the plurality of first teeth from both sides in an axial direction of the stator core;
a pair of second insulators provided separately from the pair of first insulators and sandwiching the plurality of second teeth from the both sides in the axial direction;
an A-phase winding wire applied to the first slot;
a B-phase winding wire applied to the second slot; and
a rotor rotatably provided facing a side surface of the stator core,
wherein each of the pair of first insulators includes:
a first base including a flat portion orthogonal to a rotation axis of the rotor; and
a first wall extending in the axial direction from the first base along a wall surface of the first slot, and

each of the pair of second insulators includes:

a second base including a flat portion orthogonal to the rotation axis; and

a second wall extending in the axial direction from the second base along a wall surface of the second slot.

14. The electric motor according to Claim 13, wherein

each of the plurality of second teeth includes a first communication passage extending outward in the radial direction from the first slot, and

the second insulator includes a protrusion extending from the second base toward the first communication passage.

15. The electric motor according to Claim 14, wherein the protrusion has an

extension distance in the axial direction from the second base larger than an extension distance of the second wall in the axial direction from the second base.

16. The electric motor according to any one of Claims 13 to 15, wherein each of

the pair of first insulators is provided with, at its outer circumferential portion, a portion overlapping an inner circumferential portion of each of the pair of second insulators in the axial direction.