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Insulator, stator and electric motor

Abstract

An insulator attached to a core body in an annular shape and multiple teeth protruding from the core body along a radial direction for insulating the teeth and a coil wound around the teeth includes: a tooth end surface covering part covering an axial end surface of the tooth. The tooth end surface covering part includes: an inclined part provided on a front surface of the tooth end surface covering part on a side opposite to the tooth and inclined such that its height from the axial end surface of the tooth gradually changes along the radial direction; and an inclined part parallel part and a tooth parallel part provided on a back surface of the tooth end surface covering part on the tooth side and concave in a direction away from the axial end surface of the tooth.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

(1) This application is a 371 application of the International PCT application serial no. PCT/JP2022/012158, filed on Mar. 17, 2022, which claims the priority benefits of Japan Patent Application No. 2021-099567, filed on Jun. 15, 2021. The entirety of each of the above-mentioned patent applications is hereby incorporated by reference herein and made a part of this specification.

TECHNICAL FIELD

(2) The disclosure relates to an insulator, a stator and an electric motor.

RELATED ART

(3) An electric motor includes, for example, a stator wound with a coil, and a rotor provided rotatably with respect to the stator and having a permanent magnet. The stator is made of a magnetic material, and includes an annular core body (circular core part) and teeth (magnetic pole teeth) radially protruding from the core body. A coil is wound around the teeth on the insulator. The insulator is made of an insulating resin. The insulator provides insulation between the teeth and the coil.

(4) Under such a configuration, when the coil is energized, a magnetic field is formed in the teeth. Magnetic attractive force and repulsive force are generated between this magnetic field and the permanent magnet, and the rotor is continuously rotated.

(5) Here, the torque performance of the electric motor greatly affects the space factor of the coil for generating the magnetic field. Therefore, various techniques have been proposed to improve the space factor of the coil. For example, a technique is disclosed in which the insulator is inclined such that the height from the surface of the tooth varies in a constant direction between the tip and base of the tooth. With this configuration, when the coil is wound on the insulator, the coil is wound in a constant direction. Therefore, the coil may be wound with as little space as possible, and the space factor of the coil may be improved as much as possible.

CITATION LIST

Patent Literature

(6) [Patent Literature 1] Japanese Patent Application Laid-Open No. 2002-247789

SUMMARY

Technical Problem

(7) However, in the conventional technology described above, since the insulator is inclined so that the height from the surface of the tooth varies in a constant direction between the tip and base of the tooth, the thickness of the teeth also changes without being constant. For this reason, there is a problem that heat sink marks or the like may occur when the insulator is molded with resin, and the moldability of the insulator is deteriorated.

(8) Accordingly, the disclosure provides an insulator capable of improving moldability, and a stator and an electric motor using this insulator.

Solution to Problem

(9) In view of the above, an insulator according to the disclosure is an insulator attached to a core body in an annular shape and multiple teeth protruding from the core body along a radial direction for insulating the teeth and a coil wound around the teeth, and the insulator includes: a tooth end surface covering part covering an axial end surface of the tooth. The tooth end surface covering part includes: an inclined part provided on a surface of the tooth end surface covering part on a side opposite to the tooth and inclined such that its height from the axial end surface of the tooth gradually changes along the radial direction; and a concave part provided on a surface of the tooth end surface covering part on the tooth side and concave in a direction away from the axial end surface of the tooth.

Effects of Invention

(10) According to the disclosure, it is possible to prevent an increase in the thickness of the inclined part of the insulator. Therefore, deterioration of moldability due to heat sink marks or the like may be suppressed when the insulator is resin-molded.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a perspective view of a motor with a speed reducer according to an embodiment of the disclosure.
(2) FIG. **2** is a cross-sectional view taken along the line II-II of FIG. **1**.
(3) FIG. **3** is a perspective view of a stator according to an embodiment of the disclosure.
(4) FIG. **4** is a plan view of the stator according to an embodiment of the disclosure as viewed from the axial direction, showing a state in which a terminal holder is removed.
(5) FIG. **5** is a perspective view of an insulator according to an embodiment of the disclosure.
(6) FIG. **6** is a perspective view of a first insulator according to an embodiment of the disclosure.
(7) FIG. **7** is a view in the direction of the arrow VII of FIG. **5**.
(8) FIG. **8** is a view in the direction of the arrow VIII of FIG. **6**.
(9) FIG. **9**A is a cross-sectional view taken along the line IXA-IXA of FIG. **7**.
(10) FIG. **9**B is a cross-sectional view taken along the line IXB-IXB of FIG. **7**.
(11) FIG. **9**C is a cross-sectional view taken along the line IXC-IXC of FIG. **7**.
(12) FIG. **10** is a view in the direction of the arrow X of FIG. **6**.
(13) FIG. **11** is a perspective view of a second insulator according to a first embodiment of the disclosure.
(14) FIG. **12** is a comparison illustration view of the mold according to the first embodiment of the disclosure.
(15) FIG. **13** is a plan view of the jig according to the first embodiment of the disclosure as viewed from the axial direction.
(16) FIG. **14** is a plan view showing a state in which the coil is pulled into the pull-in slit when the coil is routed clockwise according to the first embodiment of the disclosure.
(17) FIG. **15** is a perspective view showing a state in which the coil is pulled into the pull-in slit when the coil is routed clockwise according to the first embodiment of the disclosure.
(18) FIG. **16** is a plan view showing a state in which the coil is pulled into the pull-in slit when the coil is routed counterclockwise according to the first embodiment of the disclosure.
(19) FIG. **17** is a perspective view showing a state in which the coil is pulled into the pull-in slit when the coil is routed clockwise according to the first embodiment of the disclosure.
(20) FIG. **18** is a plan view showing a state in which the coil is pulled out through the pull-out slit and routed counterclockwise according to the first embodiment of the disclosure.
(21) FIG. **19** is a plan view showing a state in which the coil is pulled out through the pull-out slit and routed clockwise according to the first embodiment of the disclosure.
(22) FIG. **20** is an illustration view showing the winding state of the coil on the insulator according to the first embodiment of the disclosure.
(23) FIG. **21**A is an illustration view of an inclination angle of an inclined part according to the embodiment of the disclosure.
(24) FIG. **21**B is an illustration view of an inclination angle of an inclined part according to a comparative example.
(25) FIG. **22** is a plan view of the first insulator according to the second embodiment of the disclosure as viewed from the axial direction.
(26) FIG. **23** is a cross-sectional view taken along the line XXIII-XXIII of FIG. **22**.

DESCRIPTION OF THE EMBODIMENTS
(27) Next, an embodiment of the disclosure will be described with reference to the drawings.
(28) <Motor with Speed Reducer>
(29) FIG. **1** is a perspective view of a motor **1** with a speed reducer. FIG. **2** is a cross-sectional view taken along the line II-II of FIG. **1**.
(30) The motor **1** with a speed reducer is used, for example, as a drive source for a wiper device of a vehicle.
(31) As shown in FIGS. **1** and **2**, the motor **1** with a speed reducer includes an electric motor **2**, a speed reduction part **3** that decelerates and outputs the rotation of the electric motor **2**, and a controller **4** that controls the drive of the electric motor **2**.
(32) In the following description, in the case of simply saying the “axial direction,” it means a direction parallel to the central axis of a shaft **31** of the electric motor **2** (rotation axis C**1** of the electric motor **2**). In the case of simply saying the “circumferential direction,” it means the circumferential direction (rotation direction) of the shaft **31**. In the case of simply saying the “radial direction,” it means the radial direction of the shaft **31** perpendicular to the axial direction and the circumferential direction.
(33) <Electric Motor>
(34) The electric motor **2** includes a motor case **5**, a cylindrical stator **8** housed in the motor case **5**, and a rotor **9** provided inside the stator **8** in the radial direction and provided rotatably with respect to the stator **8**. The electric motor **2** is a so-called brushless motor that does not require a brush to supply electric power to the stator **8**.
(35) <Motor Case>
(36) The motor case **5** is made of a material having good heat dissipation property such as an aluminum alloy. The motor case **5** includes a first motor case **6** and a second motor case **7** which are configured to be separable in the axial direction. The outer shapes of the first motor case **6** and the second motor case **7** are each formed into a bottomed cylindrical shape.
(37) A bottom part **10** of the first motor case **6** is formed integrally with a gear case **40** of the speed reduction part **3**. A through hole **10***a* through which the shaft **31** of the electric motor **2** may be inserted is formed at the center of the bottom part **10** in the radial direction. Outer flange parts **16** and **17** protruding radially outward are formed in openings **6***a* and **7***a* of the first motor case **6** and the second motor case **7**, respectively. The outer flange parts **16** and **17** are butted against each other, and the first motor case **6** and the second motor case **7** are integrated with bolts **25**. The motor case **5** has an internal space closed by the first motor case **6** and the second motor case **7**, and a stator **8** and a rotor **9** are housed in this internal space.
(38) <Rotor>
(39) The rotor **9** is rotatably provided inside the stator **8** in the radial direction via a minute gap. The rotor **9** includes the shaft **31**, a cylindrical rotor core **32** fitted and fixed to the shaft **31**, multiple magnets (not shown) attached to the outer periphery of the rotor core **32**, and a magnet cover **32***a* covering the rotor core **32** from above the magnets.
(40) The shaft **31** is integrally molded with a worm shaft **44** that configures the speed reduction part **3**. However, the disclosure is not limited thereto, and the worm shaft **44** may be formed separately from the shaft **31** and connected to the end of the shaft **31**. The shaft **31** and the worm shaft **44** are rotatably supported by the gear case **40** via bearings **46** and **47**. The shaft **31** and the worm shaft **44** rotate around the rotation axis C**1**. A ferrite magnet, for example, is used as the magnet. However, the disclosure is not limited thereto, and a neodymium bond magnet, a neodymium sintered magnet, or the like may be applied as the magnet.
(41) <Speed Reduction Part>
(42) The speed reduction part **3** includes a gear case **40** integrated with the motor case **5** and a worm reduction mechanism **41** housed in the gear case **40**. The gear case **40** is made of a metal material having good heat dissipation property such as an aluminum alloy. The gear case **40** is

formed in a box shape having an opening **40***a* on one side. The gear case **40** includes a gear housing part **42** for housing the worm reduction mechanism **41** inside. Further, in a side wall **40***b* of the gear case **40**, an opening **43** is formed at a part where the first motor case **6** is integrally formed to communicate the through hole **10***a* of the first motor case **6** and the gear housing part **42**.
(43) A cylindrical bearing boss **49** protrudes from a bottom wall **40***c* of the gear case **40**. The bearing boss **49** is for rotatably supporting an output shaft **48** of the worm reduction mechanism **41**, and a slide bearing (not shown) is disposed on the inner peripheral side. An O-ring (not shown) is attached to the inner peripheral surface of the tip of the bearing boss **49**. Multiple ribs **52** are provided protruding from the outer peripheral surface of the bearing boss **49** to ensure rigidity.
(44) The worm reduction mechanism **41** housed in the gear housing part **42** is configured by a worm shaft **44** formed integrally with the shaft **31** of the rotor **9** and a worm wheel **45** meshing with the worm shaft **44**. The worm shaft **44** is rotatably supported by the gear case **40** via bearings **46** and **47** at both ends in the axial direction about the rotation axis C**1**. The output shaft **48** of the electric motor **2** is provided coaxially and integrally with the worm wheel **45**. The worm wheel **45** and the output shaft **48** are disposed such that their rotation axes are perpendicular to the rotation axis C**1** of the worm shaft **44** (the shaft **31** of the electric motor **2**). The output shaft **48** protrudes outside through the bearing boss **49** of the gear case **40**. A protruding tip of the output shaft **48** is formed with a spline **48***a* that may be connected to an object to be driven by the motor.
(45) The worm wheel **45** is also provided with a sensor magnet (not shown). The position of this sensor magnet is detected by a magnetic detection element **50** (to be described later) provided in the controller **4**. That is, the rotational position of the worm wheel **45** is detected by the magnetic detection element **50** of the controller **4**.
(46) <Controller>
(47) The controller **4** includes a controller board **51** on which the magnetic detection element **50** is mounted. The controller board **51** is disposed in the opening **40***a* of the gear case **40** so that the magnetic detection element **50** faces the sensor magnet of the worm wheel **45**. The opening **40***a* of the gear case **40** is closed with a cover **53**.
(48) The controller board **51** is electrically connected to coils **24** of the stator **8**, which will be described later. Further, terminals of the connector **11** (see FIG. **1**) provided on the cover **53** are electrically connected to the controller board **51**. In addition to the magnetic detection element **50**, a power module (not shown) including a switching element such as a field effect transistor (FET) for controlling the drive voltage supplied to the coils **24**, a capacitor (not shown) for smoothing the voltage and the like are mounted on the controller board **51**.
(49) <Stator and Terminal Holder>
(50) FIG. **3** is a perspective view of the stator **8**. FIG. **4** is a plan view of the stator **8** as viewed from the axial direction, showing a state in which a terminal holder **85** is removed. Moreover, FIG. **4** shows a part of the insulator **26** cut away.
(51) As shown in FIGS. **3** and **4**, the stator **8** includes a cylindrical stator core **20** whose center axis coincides with the rotation axis C**1**, an insulator **26** attached to the stator core **20**, and multiple coils **24** having a three-phase (U-phase, V-phase, W-phase) structure wound around the stator core **20** from above the insulator **26**.
(52) A terminal holder **85** is provided on the stator core **20**. The terminal holder **85** includes terminals **86**, a holder body **87** that holds the terminals **86**, and a cover part **88** that covers one end of the stator core **20** in the axial direction, which are integrally formed. The terminals **86** are connected to terminal parts **24***a* of the coils **24** of each phase, and to connectors (not shown) extending from the controller board **51**.
(53) The cover part **88** includes an annular end surface cover part **88***a* disposed to face the stator core **20** in the axial direction, and an outer periphery cover part **88***b* extending from the outer peripheral edge of the end surface cover part **88***a* toward the stator core **20** side and covering the insulator **26** from the outside in the radial direction, which are integrally formed.

(54) The holder body **87** is formed to rise from a part of the end surface cover part **88***a* toward the side opposite to the stator core **20**. A cut-out part **88***c* is formed in a part corresponding to the holder body **87** of the end surface cover part **88***a* and the outer periphery cover part **88***b*.
(55) The holder body **87** is formed in a rectangular parallelepiped shape extending in the axial direction and the circumferential direction. A connector (not shown) extending from the controller board **51** is attached to the holder body **87**. The holder body **87** is formed with three terminal housing recesses **87***a* disposed in the longitudinal direction when viewed from the axial direction. The terminals **86** are housed and held in these terminal housing recesses **87***a*. Then, the terminals **86** and connectors (not shown) extending from the controller board **51** are connected.
(56) The stator core **20** is formed by stacking multiple electromagnetic steel sheets **20***p*. However, the disclosure is not limited thereto, and the stator core **20** may be formed by, for example, pressure-molding soft magnetic powder.
(57) The stator core **20** includes a cylindrical core body **21**, multiple (six in this first embodiment) teeth **22** protruding radially inward from the inner peripheral surface of the core body **21**, and two fixing parts **23** integrally formed on the outer peripheral surface of the core body **21**. The tooth **22** includes a tooth body **28** protruding radially from the inner peripheral surface of the core body **21** and a collar part **29** integrally formed with a tooth tip part **28***a*, which is radially inner end of the tooth body **28** opposite to the core body **21**. The coil **24** is wound around the tooth body **28** from above the insulator **26**.
(58) The collar part **29** extends along the circumferential direction. The inner peripheral surface of the collar part **29** is formed along a circle centered on the rotation axis C**1**. Between the teeth **22** adjacent in the circumferential direction, dovetail groove-shaped slots **27** are formed by the inner peripheral surface of the core body **21**, the circumferential side surface of the tooth body **28**, and the outer peripheral surface of the collar part **29** when viewed in the axial direction.
(59) The fixing part **23** protrudes radially outward from the outer peripheral surface of the core body **21** and are disposed at intervals of 180° in the circumferential direction. A bolt insertion hole **23***a* is formed in the fixing part **23** so as to extend therethrough in the axial direction.
(60) With such a configuration, the outer peripheral surface of the core body **21** is fitted to the inner peripheral surface of the first motor case **6** and housed therein. The stator core **20** is fastened and fixed to the first motor case **6** by inserting a tapping screw (not shown) into the bolt insertion hole **23***a* of the fixing part **23** and screwing the tapping screw into the bottom part **10** of the first motor case **6**. The stator core **20** fixed in this way is covered with the second motor case **7**. Then, the second motor case **7** is fixed to the first motor case **6**.
First Embodiment
(61) <Insulator>
(62) FIG. **5** is a perspective view of the insulator **26**. FIG. **5** shows the insulator **26** attached to the stator core **20**. FIG. **6** is a perspective view of a first insulator **61** in the insulator **26**.
(63) The insulator **26** serves to provide insulation between the teeth **22** and the coils **24**, and is made of insulating resin.
(64) As shown in FIGS. **5** and **6**, the insulator **26** is axially divided into two parts so as to be attached from both sides of the stator core **20** in the axial direction. That is, the insulator **26** includes a first insulator **61** attached from one axial side (upper side in FIG. **5**) of the stator core **20** and a second insulator **62** attached from the other axial side (lower side in FIG. **5**) of the stator core **20**.
(65) In the following description, the side of the first insulator **61** will be referred to as the upper side, and the side of the second insulator **62** will be referred to as the lower side in order to facilitate understanding of the description.
(66) The first insulator **61** includes a core body covering part **63** that covers the core body **21** and a tooth covering part **64** that covers the tooth **22**, which are integrally formed. The core body covering part **63** includes an annular core end surface covering part **65** covering the axial end

surface of the core body **21**, a core side surface covering part **66** protruding downward from a lower surface **65***a* of the core end surface covering part **65**, and a cylindrical outer wall part **67** protruding upward from an upper surface **65***b* of the core end surface covering part **65**.

(67) The core side surface covering part **66** is disposed on the inner peripheral edge of the core end surface covering part **65**. The core side surface covering part **66** covers the inner peripheral surface of the core body **21**. The outer wall part **67** is disposed near the outer peripheral edge of the core end surface covering part **65**. An outer periphery cover part **88***b* of the terminal holder **85** is disposed radially outside the outer wall part **67**.

(68) A pull-in slit **68** and a pull-out slit **69** are formed in the outer wall part **67** at positions corresponding to the respective tooth covering parts **64**.

(69) The pull-in slit **68** is for pulling in the coil **24** from the radially outer side to the radially inner side of the outer wall part **67**. The pull-out slit **69** is for pulling out the coil **24** from the radially inner side to the radially outer side of the outer wall part **67**. The details of the pulling in or pulling out of the coil **24** through the slits **68**, **69** and the detailed positions of the slits **68**, **69** will be described later.

(70) The core end surface covering part **65** and the outer wall part **67** are integrally formed with a coil pull-out part **77** at the base of the tooth covering part **64**A (hereinafter, this tooth covering part **64**A is referred to as a specific tooth covering part **64**A) that covers a specific tooth **22**A (with reference to FIG. **4**, hereinafter, this tooth **22**A is referred to as the specific tooth **22**A) among the multiple teeth **22**.

(71) The coil pull-out part **77** is a part for pulling upward the terminal part **24***a* (see FIG. **3**) of the coil **24** of each phase. The terminal holder **85** is disposed such that the cut-out part **88***c* of the terminal holder **85** fits into the coil pull-out part **77**. That is, the terminal **86** of the terminal holder **85** is disposed directly above the coil pull-out part **77**.

(72) The coil pull-out part **77** has multiple (three, for example, because the coils **24** of the first embodiment have a three-phase structure) coil guide recesses **78** for separately regulating the pull-out parts of the terminal parts **24***a* of the coils **24** of each phase. These coil guide recesses **78** are collectively disposed side by side in the circumferential direction. Each coil guide recess **78** is integrally formed with a coil holding claw **78***a* protruding in the circumferential direction. The terminal parts **24***a* of the coils **24** of each phase are individually pulled out upward through the respective coil guide recesses **78**. The terminal parts **24***a* of the pulled-out coils **24** of each phase are guided to the terminals **86** of the terminal holder **85** while being held by the coil holding claws **78***a*, and are connected to the terminals **86**.

(73) FIG. **7** is a view in the direction of the arrow VII of FIG. **5**. FIG. **8** is a view in the direction of the arrow VIII of FIG. **6**. FIG. **9**A is a cross-sectional view taken along the line IXA-IXA of FIG. **7**. FIG. **9**B is a cross-sectional view taken along the line IXB-IXB of FIG. **7**. FIG. **9**C is a cross-sectional view taken along the line IXC-IXC of FIG. **7**.

(74) As shown in FIGS. **5** to **9**C, the tooth covering part **64** includes a tooth end surface covering part **71** extending from the core end surface covering part **65** along the plane direction of the core end surface covering part **65** and extending in the radial direction, a tooth side surface covering parts **72** protruding downward from both sides (two ends in the lateral direction) of the tooth end surface covering part **71** in the circumferential direction, a collar side surface covering part **73** protruding outward in the circumferential direction from the radially inner end of the tooth side surface covering part **72**, and an inner wall part **74** joined to the radially inner end of the tooth end surface covering part **71** and the upper end of the collar side surface covering part **73** and extending upward from the upper end of the collar side surface covering part **73**.

(75) The tooth end surface covering part **71** covers the upper end of the tooth body **28**. Here, the surface of the tooth end surface covering part **71** opposite to the upper end of the tooth body **28** is defined as a front surface **71***a*, and the surface facing the upper end of the tooth body **28** is defined as a back surface **71***b*. Most of the front surface **71***a* of the tooth end surface covering part **71** is

formed with an inclined part **75** over the entire radial direction. The inclined part **75** is inclined such that the height from the axial end surface of the tooth body **28** gradually decreases radially outward. In this way, the circumferential width of the inclined part **75** gradually increases radially outward.

(76) A pin contact recess (an example of a recess in the claims) **76** having a circular shape when viewed from the axial direction is formed radially inward on the front surface **71***a* of the tooth end surface covering part **71**. The pin contact recess **76** is a part with which an ejector pin of a resin molding machine (not shown) is in contact during resin molding of the first insulator **61**. The pin contact recess **76** is formed parallel to the axial end surface of the tooth body **28**.

(77) As for the detailed position of the pin contact recess **76**, a center **76***c* of the pin contact recess **76** is located radially inside a radial center **75***c* of the inclined part **75**. The pin contact recess **76** is formed so as to fit on the inclined part **75**. Since the pin contact recess **76** is disposed radially inward, the diameter is smaller than when it is disposed radially outward.

(78) The back surface **71***b* of the tooth end surface covering part **71** is formed with an inclined part parallel part **95** (concave part). The inclined part parallel part **95** is formed to correspond to the shape of the inclined part **75**. Therefore, the thickness T**1** of the tooth end surface covering part **71** is constant in the region where the inclined part parallel part **95** exists. The inclination angle θ**1** of such an inclined part **75** is smaller than 45°. The inclination angle θ**1** refers to the inclination angle with respect to the upper end (virtual plane Kp) of the tooth body **28**.

(79) Furthermore, the tooth parallel part **96** (concave part) is formed on the back surface **71***b* radially inward of the inclined part parallel part **95**. The tooth parallel part **96** is formed parallel to the axial end surface of the tooth body **28**. Therefore, the thickness T**2** of the tooth end surface covering part **71** gradually increases radially outward in the region where the tooth parallel part **96** exists. That is, T**1**<T**2**. In this way, the wall thickness of the connecting part of the tooth end surface covering part **71** with the inner wall part **74** is increased, and the strength of the inner wall part **74** may be increased. Therefore, even if a radially inward stress is applied to the inner wall part **74** due to the winding of the coil **24**, deformation of the inner wall part **74** may be suppressed.

(80) Here, the boundary line BL between the inclined part parallel part **95** and the tooth parallel part **96** is disposed along a part of the outer periphery of the pin contact recess **76** when viewed from the axial direction. Further, the tooth parallel part **96** is disposed on the back surface **71***b* in the region where the pin contact recess **76** exists. That is, the thickness T**3** of the tooth end surface covering part **71** is constant in the region where the pin contact recess **76** exists. Further, T**1**=T**3** is set.

(81) A contact part **97** provided on the same plane as the lower surface **65***a* of the core end surface covering part **65** is formed on the back surface **71***b*. The contact part **97** is in contact with the tooth body **28**. In addition, the inclined part parallel part **95** and the tooth parallel part **96** are further apart from the tooth body **28** in the axial direction than the contact part **97** is. In other words, the inclined part parallel part **95** and the tooth parallel part **96** are recessed with respect to the contact part **97**.

(82) The tooth side surface covering part **72** covers the circumferential side surface of the tooth body **28** of the tooth **22**. The collar side surface covering part **73** covers the outer peripheral surface of the collar part **29** of the tooth **22**.

(83) The tooth side surface covering part **72** and the collar side surface covering part **73**, and the core side surface covering part **66** of the core body covering part **63** are continuously formed to form a cylindrical skirt part **79** protruding downward from the tooth end surface covering part **71** and the core end surface covering part **65**. That is, skirt part **79** is interposed in the slot **27** of the stator core **20**.

(84) A tip part (an example of a skirt tip part in the claims **79***a*, which is the lower end of the skirt part **79**, is formed to be oblique so that the protruding height from the tooth end surface covering part **71** and the core end surface covering part **65** gradually changes along the circumferential direction. A flat part **79***b* parallel to the tooth end surface covering part **71** and the core end surface

covering part **65** is formed at the tip part **79***a* of the skirt part **79** where the protruding height is the lowest.
(85) Further, a parting line PL parallel to the tooth side surface covering part **72** and the collar side surface covering part **73** is set in the skirt part **79** nearer to the tip part **79***a* than the center in the vertical direction. The parting line PL is a part where an upper mold **91** and a lower mold **92** (see FIG. **12**) of a mold **90** used when resin-molding the first insulator **61** are overlapped. In other words, the parting line PL is a line along which the mold **90** used for resin molding is divided.
(86) A concave part **81** is formed on the inner side surface **79***c* of the skirt part **79** (the side surface of the tooth side surface covering part **72**, the collar side surface covering part **73**, and the core side surface covering part **66** opposite to the stator core **20**) through a small stepped part **80** over the entirety from the parting line PL to the tip part **79***a*. In this way, the thickness of the skirt part **79** is slightly thinner at the lower part than at the upper part across the parting line PL. By forming the small stepped part **80** on the parting line PL, even when the parting line PL is set in the middle of the side surface of the resin molded product (skirt part **79**), it is possible to suppress the occurrence of burrs at this parting line PL at the time of resin molding. In addition, the dimension of the small step part **80** is, for example, about 0.04 mm.
(87) FIG. **10** is a view in the direction of the arrow X of FIG. **6**.
(88) As shown in FIGS. **5**, **6**, and **10**, a pair of press-fit protrusions **82***a* and **82***b* are formed on the outer side surface **79***d* of the skirt part **79** (the side surface of the tooth side surface covering part **72**, the collar side surface covering part **73**, and the core side surface covering part **66** on the stator core **20** side) near the tooth side surface covering part **72** of the core side surface covering part **66**. The pair of press-fit protrusions **82***a* and **82***b* are disposed on two sides in the circumferential direction with the tooth covering part **64** interposed therebetween. These press-fit protrusions **82***a* and **82***b* are for press-fitting and mounting the first insulator **61** on the stator core **20**. The press-fit protrusions **82***a* and **82***b* may prevent the first insulator **61** from coming off the stator core **20**.
(89) The pair of press-fit protrusions **82***a* and **82***b* are disposed at equal intervals in the circumferential direction every other tooth covering part **64**, except for a part corresponding to the specific tooth **22**A (specific tooth covering part **64**A). In the first embodiment, since there are six teeth **22** (tooth covering parts **64**), a pair of press-fit protrusions **82***a* and **82***b* are disposed at locations corresponding to three tooth covering parts **64** disposed at equal intervals in the circumferential direction except for the specific tooth covering part **64**A.
(90) FIG. **11** is a perspective view of the second insulator **62**.
(91) As shown in FIGS. **5** and **11**, the basic configuration of the second insulator **62** is line-symmetrical with the first insulator **61** about the axial center (vertical center) of the stator core **20**. Therefore, in the following description, the same reference numerals as those of the first insulator **61** are assigned to the same configurations of the second insulator **62** as those of the first insulator **61**, and the description thereof is omitted.
(92) The difference between the first insulator **61** and the second insulator **62** is that the outer wall part **67** of the first insulator **61** is formed with a pull-in slit **68** and a pull-out slit **69**, whereas the outer wall part **83** of the second insulator **62** is not formed with the pull-in slit **68** or the pull-out slit **69**.
(93) Further, the tip part **79***a* of the skirt part **79** of the second insulator **62** is formed along the inclination direction of the tip part **79***a* of the skirt part **79** of the first insulator **61**. Therefore, when the first insulator **61** and the second insulator **62** are attached from both sides in the axial direction of the stator core **20**, a gap S (see FIG. **5**) between the tip parts **79***a* of the skirt parts **79** that face each other is constant.
(94) <Action of Insulator During Resin Molding>
(95) Next, based on FIG. **12**, the action of the insulator **26** (the first insulator **61** and the second insulator **62**) during resin molding will be described.
(96) FIG. **12** is an illustration view comparing the mold **90** used for resin-molding the first insulator

61 and the second insulator **62** with a mold **290** of a comparative example.
(97) A parting line PL parallel to the tooth side surface covering part **72** and the collar side surface covering part **73** is set on the skirt part **79** of each insulator **61** and **62**. Therefore, as shown in FIG. **12**, the parting line PL is perpendicular to the mold clamping and mold release direction Y**1** between the upper mold **91** and the lower mold **92** in the mold **90**. Therefore, when the mold **90** is clamped, no clamping force is applied to the upper mold **91** or the lower mold **92** in the direction perpendicular to the mold clamping and mold release direction Y**1**, and the positional deviation of the upper mold **91** or the lower mold **92** is prevented. Therefore, the resin molding accuracy of the insulator **26** is improved.
(98) In contrast, for example, when the parting line PL is set on the skirt part **79** of each insulator **61** and **62** along the tip part **79***a*, as in the mold **290** of the comparative example, the mold clamping between the upper mold **291** and the lower mold **292** and the parting line PL are oblique to the mold release direction Y**21**, not perpendicular thereto. Therefore, when the mold **290** is clamped, a clamping force is applied to the upper mold **291** and the lower mold **292** in a direction perpendicular to the mold release direction Y**21**, and the upper mold **291** and the lower mold **292** may be displaced. Therefore, the resin molding accuracy of the insulator **26** is lowered.
(99) By the way, when measuring the molding accuracy of the insulator **26**, it is difficult to measure the skirt part **79** because the tip part **79***a* thereof is obliquely formed. That is, in measuring the skirt part **79**, the reference position is the lower surface **65***a* of the core end surface covering part **65**, for example. In this case, it is easy to identify the tip of the skirt part **79** protruding from the lower surface **65***a*, but it is difficult to identify the part where the protruding height of the skirt part **79** is lowest.
(100) A more specific description will be given with reference to the enlarged part of FIG. **6**. The enlarged part of FIG. **6** is viewed from a direction perpendicular to the axial direction for the sake of clarity of description, and the scale is appropriately changed.
(101) For example, when the skirt part **79** is measured with the lower surface **65***a* of the core end surface covering part **65** as a reference using a three-dimensional measuring machine m or the like, the tip of the skirt part **79** is likely to come into contact with the probe Pr. In addition, since the probe Pr has a spherical shape, at the part where the protruding height of the skirt part **79** is the lowest, the probe Pr contacts a slightly higher inclined part than this point (see the contact point Pj in FIG. **6**), and it becomes an obstacle when the probe Pr comes into contact with the part of the skirt part **79** where the protruding height is the lowest. Therefore, it is difficult to reliably bring the probe Pr into contact with the part of the skirt part **79** where the protruding height is the lowest.
(102) Here, in the first embodiment, the flat part **79***b* is formed at the tip part **79***a* of the skirt part **79** where the protruding height is the lowest. Therefore, it is possible to easily identify the part where the skirt part **79** has the lowest protruding height. Further, when measuring the skirt part **79** with the lower surface **65***a* of the core end surface covering part **65** as a reference using, for example, a three-dimensional measuring machine m, the probe Pr may be reliably brought into contact with the part where the protruding height of the skirt part **79** is lowest. Therefore, the insulator **26** may be measured with high accuracy.
(103) <Insulator Assembly and Action of the Insulator during Assembly>
(104) Next, action of the insulator **26** during assembly will be described with reference to FIGS. **6**, **10** and **13**.
(105) FIG. **13** is a plan view of a jig **93** used when assembling the first insulator **61** of the insulator **26** to the stator core **20** as viewed from the axial direction. The second insulator **62** is assembled to the stator core **20** in the same manner as the first insulator **61** using the same jig **93** as the first insulator **61**, so the description thereof will be omitted.
(106) As shown in FIGS. **6** and **13**, when the first insulator **61** is assembled to the stator core **20**, the skirt part **79** of the first insulator **61** is axially above stator core **20** and directed downward (toward the stator core **20** side). In this state, the jig **93** presses the outer wall part **67** of the first

insulator **61** from above the first insulator **61**.
(107) The jig **93** is formed in a columnar shape to correspond to the shape of the first insulator **61**. The outer diameter of the jig **93** is slightly larger than the outer diameter of the core end surface covering part **65** of the first insulator **61**. A chamfered part **93***a* is formed in the jig **93** at a position corresponding to the coil pull-out part **77** of the first insulator **61**. In this way, when the jig **93** presses the first insulator **61**, the jig **93** may be prevented from coming into contact with the coil pull-out part **77**, and the first insulator **61** may be stably pressed by the jig **93**.
(108) When the jig **93** presses the first insulator **61**, the skirt part **79** is first inserted into the slot **27** of the stator core **20**. At this time, since the tip part **79***a* of the skirt part **79** is formed obliquely, the tip part **79***a* of the skirt part **79** is not inserted into the slot **27** all at once. That is, the skirt part **79** is gradually inserted into the slot **27** from the tip of the skirt part **79**. Therefore, the tip part **79***a* of the skirt part **79** serves as a guide, and the skirt part **79** is smoothly inserted into the slot **27**.
(109) When the jig **93** presses the first insulator **61**, the outer side surface **79***d* of the skirt part **79** is fitted to the stator core **20**. At this time, the first insulator **61** is press-fitted into the stator core **20** by the press-fit protrusions **82***a* and **82***b* formed on the skirt part **79**.
(110) Here, the chamfered part **93***a* is formed in the jig **93** at a position corresponding to the coil pull-out part **77** of the first insulator **61**. Therefore, the jig **93** does not press the specific tooth covering part **64**A where the coil pull-out part **77** is disposed and the periphery of the specific tooth covering part **64**A.
(111) In addition, the press-fit protrusions **82***a* and **82***b* are disposed at equal intervals in the circumferential direction every other tooth covering part **64**, except for the part corresponding to the specific tooth covering part **64**A. Therefore, the press-fit protrusions **82***a* and **82***b* are evenly pressed. In addition, slight deformation of the first insulator **61** that occurs when the press-fit protrusions **82***a* and **82***b* are pushed into the stator core **20** is evenly dispersed on the tooth covering part **64** where the press-fit protrusions **82***a* and **82***b* are not formed and on the periphery of this tooth covering part **64**. In this way, the first insulator **61** is reliably press-fitted into the stator core **20** and attached.
(112) <Winding Method of Coil and Detailed Positions of Pull-In Slit and Pull-Out Slit>
(113) Next, a winding method of the coil **24** wound from above the insulator **26** attached to the stator core **20** and the detailed positions of the pull-in slit **68** and the pull-out slit **69** formed in the first insulator **61** of the insulator **26** will be described based on FIGS. **4** and **14** to **19**.
(114) First, as shown in FIG. **4**, as a method of winding the coil **24**, the coil **24** is wound around the tooth **22** from above the insulators **61** and **62** by a so-called concentrated winding method. More specifically, the coils **24** of each phase are wound in series on the teeth **22** of the corresponding phase while being routed over the core end surface covering part **65** of the first insulator **61**.
(115) That is, for example, since the electric motor **2** of the first embodiment has a three-phase structure, the teeth **22** of the same phase are disposed every two teeth **22** in the circumferential direction. For example, since there are six teeth **22** in the first embodiment, the coil **24** of each phase is continuously wound around the two teeth **22** while being routed over the core end surface covering part **65** of the first insulator **61**.
(116) At this time, the coil **24** routed over the core end surface covering part **65** of the first insulator **61** is pulled toward the tooth covering part **64** through the pull-in slit **68** of the first insulator **61**. Then, the coil **24** is wound around the tooth **22** from above the tooth covering part **64**.
(117) After that, the coil **24** wound around the tooth covering part **64** (tooth **22**) is pulled out again onto the core end surface covering part **65** via the pull-out slit **69** of the first insulator **61**. Then, the coil is guided to the terminal **86** of the terminal holder **85** via the coil guide recess **78** and connected to the terminal **86**.
(118) The coil **24** pulled into the pull-in slit **68** may be routed over the core end surface covering part **65** to straddle the base of the corresponding tooth covering part **64** (tooth **22**) (counterclockwise CCW in FIG. **4**). After that, it may be pulled into the tooth covering part **64** side

through the pull-in slit **68**. Hereinafter, this case will be referred to as the case where the coil **24** is routed counterclockwise CCW.

(119) Further, the coil **24** pulled into the pull-in slit **68** may be routed over the core end surface covering part **65** from the direction opposite to the corresponding tooth covering part **64** (tooth **22**) (clockwise CW in FIG. **4**). After that, it may be pulled into the tooth covering part **64** side through the pull-in slit **68**. Hereinafter, this case will be referred to as the case where the coil **24** is routed clockwise CW.

(120) Next, the detailed position of the pull-in slit **68** will be described with reference to FIGS. **14** to **17**.

(121) FIG. **14** is a plan view of the first insulator **61** viewed from the axial direction, showing a state in which the coil **24** is pulled into the pull-in slit **68** when the coil **24** is routed clockwise CW. FIG. **15** is a perspective view of the first insulator **61** showing a state in which the coil **24** is pulled into the pull-in slit **68** when the coil **24** is routed clockwise CW. FIG. **16** is a plan view of the first insulator **61** viewed from the axial direction, showing a state in which the coil **24** is pulled into the pull-in slit **68** when the coil **24** is routed counterclockwise CCW. FIG. **17** is a perspective view of the first insulator **61** showing a state in which the coil **24** is pulled into the pull-in slit **68** when the coil **24** is routed counterclockwise CCW.

(122) As shown in FIGS. **14** to **17**, the pull-in slit **68** is disposed on a side surface covering part straight line L passing through the tooth side surface covering part **72** of the corresponding tooth covering part **64** when viewed from the axial direction. More specifically, when viewed from the axial direction, the first side **68***a* and the second side **68***b* facing each other in the circumferential direction of the pull-in slit **68** are disposed on two sides of the side surface covering part straight line L.

(123) Here, the position of the pull-in slit **68** is slightly different depending on the routing direction of the coil **24** pulled into the pull-in slit **68**.

(124) As shown in FIG. **14**, the pull-in slit **68** into which the coil **24** routed clockwise CW is pulled is disposed so that its width W**1** between the side surface covering part straight line L and the first side **68***a* when viewed from the axial direction is smaller than the wire diameter D of the coil **24**.

(125) Therefore, as shown in FIGS. **14** and **15**, the coil **24** that is routed clockwise CW is pulled in through the pull-in slit **68** to the tooth covering part **64** side, and then is wound on the tooth covering part **64** along the tooth side surface covering part **72** on the side surface covering part straight line L in a slightly folded manner. Therefore, the coil **24** is wound on the tooth covering part **64** at the base of the tooth **22**. The occurrence of a gap between the tooth covering part **64** and the coil **24** is suppressed as much as possible.

(126) As shown in FIG. **16**, the pull-in slit **68** into which the coil **24** routed counterclockwise CCW is pulled is disposed so that its width W**2** between the side surface covering part straight line L and the second side **68***b* when viewed from the axial direction is larger than the wire diameter D of the coil **24**.

(127) Therefore, as shown in FIGS. **16** and **17**, the coil **24** that is routed counterclockwise CCW is pulled in through the pull-in slit **68** to the tooth covering part **64** side, and then is wound on the tooth covering part **64** along the tooth side surface covering part **72** on the side surface covering part straight line L in such a manner as to ride on the tooth end surface covering part **71**. Therefore, the coil **24** is wound on the tooth covering part **64** at the base of the tooth **22**. The occurrence of a gap between the tooth covering part **64** and the coil **24** is suppressed as much as possible.

(128) Next, the detailed position of the pull-out slit **69** will be described with reference to FIGS. **18** and **19**.

(129) FIG. **18** is a plan view of the first insulator **61** viewed from the axial direction, showing a state in which the coil **24** routed clockwise CW is pulled through the pull-in slit **68** to the tooth covering part **64** side and then pulled out through the pull-out slit **69**. FIG. **19** is a plan view of the first insulator **61** viewed from the axial direction, showing a state in which the coil **24** routed

counterclockwise CCW is pulled in through the pull-in slit **68** to the tooth covering part **64** side, and then pulled out through the pull-out slit **69**.
(130) As shown in FIG. **18**, the coil **24** that has been routed clockwise CW and wound through the pull-in slit **68** is pulled out radially outward through the pull-out slit **69** and then routed clockwise CW again.
(131) As shown in FIG. **19**, the coil **24** that has been routed counterclockwise CCW and wound through the pull-in slit **68** is pulled out radially outward through the pull-out slit **69** and then routed counterclockwise CCW again.
(132) Here, as shown in FIGS. **18** and **19**, the position of the pull-out slit **69** does not change whether the coil **24** is routed clockwise CW or counterclockwise CCW. That is, the pull-out slit **69** is disposed on the side opposite to the pull-in slit **68** across the circumferential center C**2** of the tooth covering part **64** (the tooth body **28** of the tooth **22**). In addition, the pull-in slit **69** is disposed in an area Ar between a first straight line Ld**1** passing through the circumferential center C**2** of the tooth covering part **64** and the rotation axis C**1**, and a second straight line Ld**2** passing through the circumferential end of the collar part **29** of the tooth **22** and the rotation axis C**1**. Therefore, when the coil **24** wound around the tooth **22** is pulled out radially outward through the pull-out slit **69**, there is no large gap between the pulled-out coil **24** and the wound coil **24**.
(133) <Winding State of Coil and Action of Inclined Part>
(134) Next, the winding state of the coil **24** and the action of the inclined parts **75** in the insulators **61** and **62** will be described with reference to FIGS. **20**, **21**A, and **21**B.
(135) FIG. **20** is an illustration view showing the winding state of the coil **24** on the insulator **26**. FIG. **20** corresponds to a plan view of the first insulator **61** viewed from above. FIG. **21**A is an illustration view of the inclination angle of the inclined part **75**. FIG. **21**B is an illustration view of the inclination angle of a comparative example.
(136) As shown in FIG. **20**, the coil **24** is spirally wound in order from the base side of the tooth **22** (the tooth covering part **64**) to the radially inner side.
(137) At this time, as shown in FIG. **21**A, the inclined part **75** formed on the tooth end surface covering part **71** allows the coil **24** to slide down toward the base of the tooth **22** and be wound forward (see arrow Y**1** in FIG. **21**A). That is, the coil **24** is wound while being packed toward the base of the teeth **22**. Therefore, no unnecessary gap is formed between the wound coil **24**.
(138) Moreover, the center **76***c* of the pin contact recess **76** used when resin-molding the insulator **26** is located radially inside the radial center **75***c* of the inclined part **75**. Further, the pin contact recess **76** is formed to fit on the inclined part **75**. Since the pin contact recess **76** is disposed radially inside, the diameter is smaller than when it is disposed radially outside. As a result, the coil **24** smoothly slides down toward the base of the tooth **22** along the inclined part **75** as compared with the case where the center **76***c* of the pin contact recess **76** is located radially outward of the radial center **75***c* of the inclined part **75**.
(139) Here, the inclination angle θ**1** of the inclined part **75** is smaller than 45°. Further, Lk is defined as an inclined straight line that is inclined by 45° with respect to a vertical straight line Ls that passes through the center of the coil **24** and is parallel to the rotation axis C**1**. The contact point Sp of the later-wound coil **24** (hereinafter referred to as the later coil **24**) with respect to the earlier-wound coil **24** (hereinafter referred to as the earlier coil **24**) is located axially inside the inclined straight line Lk of the earlier coil **24**. Therefore, the later coil **24** does not ride over the earlier coil **24**.
(140) For example, as shown in FIG. **21**B, when the inclination angle θ**1**′ of the inclined part **75** is greater than 45°, the contact point Sp′ of the later coil **24** with respect to the earlier coil **24** is located on the inclined straight line Lk of the coil **24** or axially outside the inclined straight line Lk. Therefore, the later coil **24** may ride over the earlier coil **24**. Therefore, by setting the inclination angle θ**1** of the inclined part **75** to be smaller than 45°, the wound coil **24** is prevented from being unwound.

(141) Under such a configuration, interlinkage magnetic flux is formed in the stator core **20** when power is supplied to each coil **24** via the controller **4**. Magnetic attraction and repulsion are generated between this interlinkage magnetic flux and the magnet (not shown) of the rotor **9**, and the rotor **9** is continuously rotated.
(142) When the rotor **9** is rotated, the worm shaft **44** integrated with the shaft **31** is rotated. Further, the worm wheel **45** meshed with the worm shaft **44** is rotated. Rotation of the worm wheel **45** is transmitted to the output shaft **48** connected to the worm wheel **45**. In this way, a desired electrical component connected to the output shaft **48** is driven.
(143) As described above, in the above-described first embodiment, the inclined parts **75** are formed on the front surfaces **71***a* of the tooth end surface covering parts **71** of the insulators **61** and **62**. The inclined part **75** is inclined such that the height from the axial end surface of the tooth body **28** gradually decreases radially outward. Further, the back surface **71***b* of the tooth end surface covering part **71** is formed with the inclined part parallel part **95** and the tooth parallel part **96**. Since the inclined part parallel part **95** is formed parallel to the inclined part **75**, the thickness T**1** of the tooth end surface covering part **71** is constant in the region where the inclined part parallel part **95** exists. Furthermore, since the tooth parallel part **96** is formed parallel to the pin contact recess **76**, the thickness T**3** of the tooth end surface covering part **71** is constant in the region where the pin contact recess **76** exists. Therefore, the height of the inclined part **75** from the axial end surface of the tooth body **28** is formed to gradually decrease toward the radially outer side, and even if the pin contact recess **76** is formed parallel to the upper end of the tooth body **28**, the thickness of most of the tooth end surface covering parts **71** may be made constant. That is, it is possible to prevent an increase in the thickness of the inclined parts **75** of the insulators **61** and **62**. As a result, deterioration of moldability due to heat sink marks or the like may be suppressed when the insulators **61** and **62** are resin-molded. The resin molding accuracy of the insulators **61** and **62** may be improved.
(144) Since the resin molding accuracy of the insulators **61** and **62** may be improved, it is possible to contribute to Goal 12 of Sustainable Development Goals (SDGs) led by the United Nations, "ensure sustainable consumption and production patterns."
(145) The teeth **22** radially protrude from the inner peripheral surface of the core body **21**. In contrast, the inclined part **75** is inclined such that the height from the axial end surface of the tooth body **28** gradually decreases radially outward. The coil **24** wound from above the insulator **26** starts winding from the base side of the teeth **22**. Therefore, the coil **24** is wound while being packed toward the base of the teeth **22**. It is possible to prevent unnecessary gaps from being formed between the wound coil **24**. Therefore, the space factor of the coil **24** may be reliably improved.
(146) The inclination angle θ**1** of the inclined part **75** is smaller than 45°. Therefore, the contact point Sp of the later coil **24** with respect to the earlier coil **24** may be located axially inside the inclined straight line Lk of the earlier coil **24**. Therefore, it is possible to prevent the later coil **24** from riding over the earlier coil **24**, and prevent the unwinding of the coil **24**.
(147) The tip part **79***a* of the skirt part **79** formed on each insulator **61** and **62** is formed to be oblique so that the protruding height from the tooth end surface covering part **71** and the core end surface covering part **65** gradually changes along the circumferential direction. Therefore, when the skirt part **79** is inserted into the slot **27** of the stator core **20** (when the insulators **61** and **62** are attached to the core body **21** and the teeth **22**), the skirt part **79** may be gradually inserted into the slot **27** from the tip of the skirt part **79**. Therefore, the tip part **79***a* of the skirt part **79** serves as a guide, and the insulators **61** and **62** of the stator core **20** may be easily attached.
(148) Further, the flat part **79***b* parallel to the tooth end surface covering part **71** and the core end surface covering part **65** is formed at the tip part **79***a* of the skirt part **79** where the protruding height is the lowest. Therefore, it is possible to easily identify the part where the skirt part **79** has the lowest protruding height. Further, when measuring the skirt part **79** with the lower surface **65***a* of the core end surface covering part **65** as a reference using, for example, a three-dimensional

measuring machine m, the probe Pr may be reliably brought into contact with the part where the protruding height of the skirt part **79** is lowest. Therefore, the insulator **26** may be measured with high accuracy.
(149) While the tip part **79***a* of the skirt part **79** is formed obliquely, a parting line PL parallel to the tooth side surface covering part **72** and the collar side surface covering part **73** is set on the skirt part **79**. Therefore, the parting line PL may be perpendicular to the mold clamping and mold release direction Y**1** between the upper mold **91** and the lower mold **92** in the mold **90**. Therefore, when the mold **90** is clamped, no clamping force is applied to the upper mold **91** or the lower mold **92** in the direction perpendicular to the mold clamping and mold release direction Y**1**, and the positional deviation of the upper mold **91** or the lower mold **92** may be prevented. Therefore, the resin molding accuracy of the insulator **26** may be improved.
(150) Further, the concave part **81** is formed on the inner side surface **79***c* of the skirt part **79** (the side surface of the tooth side surface covering part **72**, the collar side surface covering part **73**, and the core side surface covering part **66** opposite to the stator core **20**) through the small stepped part **80** over the entirety from the parting line PL to the tip part **79***a*. Therefore, even when the parting line PL is set in the middle of the side surface of the resin molded product (skirt part **79**), it is possible to suppress the occurrence of burrs at this parting line PL at the time of resin molding.
(151) The core end surface covering part **65** and the outer wall part **67** are integrally formed with a coil pull-out part **77** collectively disposed at the base of the specific tooth **22**A (the specific tooth covering part **64**A). The pair of press-fit protrusions **82***a* and **82***b* for press-fitting each insulator **61** and **62** into the stator core **20** are disposed at equal intervals in the circumferential direction every other tooth covering part **64**, except for a part corresponding to the specific tooth **22**A (specific tooth covering part **64**A).
(152) By forming the press-fit protrusions **82***a* and **82***b*, the insulators **61** and **62** are press fitted when attached to the stator core **20** (core body **21**). Therefore, the insulators **61** and **62** are less likely to come off from the stator core **20**.
(153) In addition, since the pair of press-fit protrusions **82***a* and **82***b* are disposed at equal intervals in the circumferential direction for every tooth covering part **64**, the jig **93** may evenly press the press-fit protrusions **82***a* and **82***b*. In addition, slight deformation of the first insulator **61** that occurs when the press-fit protrusions **82***a* and **82***b* are pushed into the stator core **20** (core body **21**) may be evenly dispersed on the tooth covering part **64** where the press-fit protrusions **82***a* and **82***b* are not formed and on the periphery of this tooth covering part **64**. As a result, distorted deformation of the insulators **61** and **62** may be suppressed.
(154) Moreover, for example, when the insulators **61** and **62** are pressed using the jig **93**, the jig **93** is pressed while avoiding the coil pull-out part **77**, which is a part of the deformed part (see FIG. **13**). Therefore, by forming the press-fit protrusions **82***a* and **82***b* while avoiding the specific tooth **22**A on which the coil pull-out part **77** is disposed, the press-fit protrusions **82***a* and **82***b* may be evenly pressed by the jig **93**. Therefore, the insulators **61** and **62** may be reliably attached to the stator core **20** (core body **21**).
(155) The center **76***c* of the pin contact recess **76** used when resin-molding the insulator **26** is located radially inside the radial center **75***c* of the inclined part **75**. Further, the pin contact recess **76** is formed to fit on the inclined part **75**. Since the pin contact recess **76** is disposed radially inside, the diameter is smaller than when it is disposed radially outside. As a result, the coil **24** smoothly slides down toward the base of the tooth **22** along the inclined part **75** as compared with the case where the center **76***c* of the pin contact recess **76** is located radially outward of the radial center **75***c* of the inclined part **75**. That is, when the coil **24** is moved in one direction along the inclined part **75**, it is possible to prevent the pin contact recess **76** from hindering the movement of the coil **24**. Therefore, the coil **24** may be disposed on the inclined part **75** without a gap.
(156) The pull-in slit **68** into which the coil **24** routed clockwise CW is pulled is disposed so that its width W**1** between the side surface covering part straight line L and the first side **68***a* when viewed

from the axial direction is smaller than the wire diameter D of the coil **24**. Therefore, the coil **24** that is routed clockwise CW is pulled in through the pull-in slit **68** to the tooth covering part **64** side, and then is wound on the tooth covering part **64** along the tooth side surface covering part **72** on the side surface covering part straight line L in a slightly folded manner. Therefore, the coil **24** is wound on the tooth covering part **64** at the base of the tooth **22**. The occurrence of a gap between the tooth covering part **64** and the coil **24** may be suppressed as much as possible. Therefore, the insulator **26** and the coil **24** may be brought into close contact with each other at the base of the tooth **22**, and the space factor of the coil **24** may be improved.
(157) The pull-in slit **68** into which the coil **24** routed counterclockwise CCW is pulled is disposed so that its width W**2** between the side surface covering part straight line L and the second side **68***b* when viewed from the axial direction is larger than the wire diameter D of the coil **24**. Therefore, the coil **24** that is routed counterclockwise CCW is pulled in through the pull-in slit **68** to the tooth covering part **64** side, and then is wound on the tooth covering part **64** along the tooth side surface covering part **72** on the side surface covering part straight line L in such a manner as to ride on the tooth end surface covering part **71**. Therefore, the coil **24** is wound on the tooth covering part **64** at the base of the tooth **22**. The occurrence of a gap between the tooth covering part **64** and the coil **24** may be suppressed as much as possible. Therefore, the insulator **26** and the coil **24** may be brought into close contact with each other at the base of the tooth **22**, and the space factor of the coil **24** may be improved.
(158) The pull-in slit **69** is disposed in an area Ar between the first straight line Ld**1** passing through the circumferential center C**2** of the tooth covering part **64** and the rotation axis C**1**, and the second straight line Ld**2** passing through the circumferential end of the collar part **29** of the tooth **22** and the rotation axis C**1**. Therefore, when the coil **24** wound around the tooth **22** is pulled out radially outward through the pull-out slit **69**, it is possible to suppress a large gap between the pulled-out coil **24** and the wound coil **24**. Therefore, the coil **24** wound around the tooth **22** may be reliably wound, and the space factor of the coil **24** may be improved.
(159) By improving the space factor of the coil **24**, the torque performance of the electric motor **2** may be improved. Therefore, energy consumption when the electric motor **2** is driven may be suppressed. Therefore, it is possible to contribute to Goal 7 of the Sustainable Development Goals (SDGs) led by the United Nations, "ensure access to affordable, reliable, sustainable and modern energy for all."
Second Embodiment
(160) Next, a second embodiment of the disclosure will be described based on FIGS. **22** and **23**. The same reference numerals are assigned to the same configurations as in the first embodiment.
(161) FIG. **22** is a plan view of a tooth covering part **264** of a first insulator **261** according to the second embodiment as viewed from the axial direction. FIG. **23** is a cross-sectional view taken along the line XXIII-XXIII of FIG. **22**.
(162) The second embodiment has the same basic configuration as that of the above-described first embodiment, in that the stator **8** includes a cylindrical stator core **20** whose center axis coincides with the rotation axis C**1**, an insulator **26** attached to the stator core **20**, and multiple coils **24** having a three-phase (U-phase, V-phase, W-phase) structure wound around the stator core **20** from above the insulator **26**, and in that the insulator **26** includes a first insulator **61** attached from one axial side of the stator core **20** and a second insulator **62** attached from the other axial side of the stator core **20**.
(163) As in the first embodiment described above, the basic configuration of the second insulator **62** in the second embodiment is line-symmetrical with the first insulator **261** about the axial center (vertical center) of the stator core **20**. Therefore, the second insulator **62** in the second embodiment has the same reference numerals as in the first embodiment, and the description thereof is omitted.
(164) As shown in FIGS. **22** and **23**, the difference between the first embodiment described above and the second embodiment is that the shape of the tooth end surface covering part **71** in the first

embodiment and the shape of the tooth end surface covering part **271** in the second embodiment are different.
(165) More specifically, the front surface **271***a* of the tooth end surface covering part **271** of the second embodiment is provided with an inclined part **275***a* formed radially outward of a radial center **271***c* of the tooth end surface covering part **271** and a non-inclined part **275***b* formed radially inward of the radial center **271***c* of the tooth end surface covering part **271**. The inclined part **275***a* is inclined such that the height from the axial end surface of the tooth body **28** gradually decreases radially outward. The non-inclined part **275** *b* is formed parallel to the axial end surface of the tooth body **28**.
(166) Further, a pin contact recess **276** is formed on the front surface **271***a* of the tooth end surface covering part **271**. The pin contact recess **276** is a part with which an ejector pin of a resin molding machine (not shown) is in contact during resin molding of the first insulator **61**.
(167) A center **276***c* of the pin contact recess **276** is located slightly radially outward of a radial center **271***c* of the tooth end surface covering part **271**. The diameter of the pin contact recess **276** is larger than the diameter of the pin contact recess **76** of the first embodiment.
(168) Further, the back surface **271***b* of the tooth end surface covering part **271** on the side of the tooth body **28** is provided with an inclined part parallel part **295** formed to correspond to the shape of the inclined part **275***a*, a tooth parallel part **296** formed parallel to the axial end surface of the tooth body **28**, and a contact part **297** that contacts the axial end surface of the tooth body **28**. Therefore, the thickness T**4** of the inclined part **275***a*, the thickness T**5** of the non-inclined part **275***b*, and the thickness T**6** of the pin contact recess **276** are all constant. Furthermore, the thickness of the entire tooth end surface covering part **71** is constant. In addition, the inclination angle θ**2** of the inclined part **275***a* is smaller than 45°.
(169) Therefore, according to the above-described second embodiment, the inclined part **275***a* has the same effect as the above-described first embodiment. In addition, since the thickness of the entire tooth end surface covering part **271** is constant, deterioration of moldability due to heat sink marks or the like may be suppressed when the insulators **261** and **62** are resin-molded. The resin molding accuracy of the insulators **261** and **62** may be improved.
(170) The disclosure is not limited to the above-described embodiment, and includes various modifications to the above-described embodiment without departing from the spirit of the disclosure.
(171) For example, in the above-described embodiment, the case where the motor **1** with a speed reducer is used, for example, as a drive source for a wiper device of a vehicle has been described. However, the disclosure is not limited thereto, and the motor **1** with a speed reducer may be applied as various drive devices. In addition, among the motors **1** with a speed reducer, only the electric motors **2** having the above configuration may be employed in various electric devices.
(172) In the second embodiment described above, the case where the non-inclined part **275***b* is formed parallel to the axial end surface of the tooth body **28** has been described. However, the disclosure is not limited thereto, and the non-inclined part **275***b* may be formed to be inclined at an angle smaller than the inclination angle θ**2** of the inclined part **275***a*.
(173) In the above-described embodiments, the case where the inclined parts **75** and **275***a* are inclined such that the height from the axial end surface of the tooth body **28** gradually decreases radially outward has been described. However, the disclosure is not limited thereto, and the inclination direction of the inclined parts **75** and **275***a* may be changed according to the direction in which the teeth **22** protrude. That is, when the teeth **22** protrude radially outward, the base of the teeth **22** are located radially inward from the tips of the teeth **22**. In such a case, the height of the inclined parts **75** and **275***a* from the axial end surface of the tooth body **28** may be inclined to gradually decrease radially inward.
(174) In the above-described embodiments, the coil **24** of the stator **8** has a three-phase (U-phase, V-phase, W-phase) structure. However, the number of phases of the coil **24** is not limited to three.

Claims

1. An insulator, adapted to be attached to a core body having an annular shape and a plurality of teeth protruding along a radial direction from the core body, the insulator is adapted for insulating the teeth and a coil wound around the teeth, each tooth of the plurality of teeth being a tooth that protrudes radially inward from an inner surface of the core body and has an axial end surface facing toward an axial direction of the core body, the insulator comprising: a tooth end surface covering part configured to cover the axial end surface of the tooth, wherein the tooth end surface covering part comprises: a front surface configured to face away from the axial end surface of the tooth; a back surface opposite to the front surface, the back surface configured to face toward the axial end surface of the tooth; an inclined part configured on the front surface of the tooth end surface covering part and inclined such that a height of the inclined part gradually changes along the radial direction; and a concave part configured on the back surface of the tooth end surface covering part and being concaved toward the inclined part in a direction away from the axial end surface of the tooth, wherein the concave part comprises: an inclined part parallel part provided parallel to the inclined part; and a tooth parallel part provided parallel to a horizontal plane parallel to the axial end surface of the tooth.
2. The insulator according to claim 1, wherein the inclined part is inclined such that the height of the inclined part with respect to the horizontal plane, gradually decreases along the radial direction from a side close to an axial center of the core body toward a side away from the axial center of the core body.
3. The insulator according to claim 1, wherein the tooth parallel part is disposed closer to an axial center of the core body in the radial direction than the inclined part parallel part.
4. The insulator according to claim 1, comprising: a core end surface covering part covering an axial end surface of the core body; a core side surface covering part covering an inner peripheral surface of the core body; a tooth side surface covering part covering a circumferential side surface of a tooth body extending along the radial direction; and a collar side surface covering part covering an outer peripheral surface of a collar part integrally formed with a tooth tip part of the tooth body in the radial direction on a side close to an axial center of the core body and extends in a circumferential direction, wherein a skirt tip part of a skirt part formed by connecting the core side surface covering part, the tooth side surface covering part, and the collar side surface covering part on a side opposite to the core end surface covering part is obliquely formed such that its protruding height from the core end surface covering part changes gradually along the circumferential direction, and the skirt part comprises a flat part formed at a part of the skirt tip part where the protruding height is lowest and parallel to the core end surface covering part.
5. The insulator according to claim 1, comprising: a core end surface covering part covering an axial end surface of the core body; a core side surface covering part covering an inner peripheral surface of the core body; a tooth side surface covering part covering a circumferential side surface of a tooth body extending along the radial direction of the tooth; a collar side surface covering part covering an outer peripheral surface of a collar part, which is integrally formed with a tooth tip part of the tooth body in the radial direction on a side close to an axial center of the core body and extends in a circumferential direction; a coil pull-out part formed in the core end surface covering part, collectively disposed at a base of one specific tooth among the plurality of teeth, and from which a terminal part of the coil is pulled out; and a pair of press-fit protrusions formed near the tooth side surface covering part of the core side surface covering part for press-fitting the core side surface covering part into the core body, wherein the pair of press-fit protrusions are disposed at equal intervals in the circumferential direction at positions corresponding to at least every other tooth in the circumferential direction of the plurality of teeth excluding the specific tooth.
6. The insulator according to claim 1, wherein the insulator comprises a resin-molded product and

comprises a recess formed in the inclined part of the front surface, the recess being configured to be abutted by an ejector pin of a resin molding machine during resin molding of the insulator, wherein a center of the recess is located radially inward from a radial center of the inclined part.

7. The insulator according to claim 6, wherein a boundary line between the inclined part parallel part and the tooth parallel part is disposed along a part of an outer periphery of the recess part when viewed from an axial direction of the tooth.

8. A stator comprising: the insulator according to claim 1; the core body in an annular shape and configured to be attached with the insulator; the teeth protruding inward from an inner peripheral surface of the core body along the radial direction; and the coil wound around the teeth via the insulator while being routed along the core body, wherein the insulator comprises: a tooth side surface covering part covering a circumferential side surface of a tooth body extending along the radial direction of the tooth; an outer wall part protruding along an axial direction from a radially outer end of the inclined part; and an inner wall part protruding along the axial direction from a radially inner end of the inclined part, wherein the outer wall part comprises a pull-in slit formed for each of the teeth for pulling in the coil from a radially outer side to a radially inner side of the outer wall part, a first side and a second side of the pull-in slit facing each other in a circumferential direction are disposed on two sides of a side surface covering part straight line passing through the tooth side surface covering part when viewed from the axial direction, the second side is disposed closer to a circumferential center of the tooth than the first side is, in a case where the coil is pulled into the pull-in slit by being routed to straddle a base of the corresponding tooth, a width between the side surface covering part straight line and the second side when viewed from the axial direction is larger than a wire diameter of the coil, and in a case where the coil is pulled into the pull-in slit by being routed in an opposite direction to the corresponding teeth, a width between the side surface covering part straight line and the first side when viewed from the axial direction is smaller than the wire diameter of the coil.

9. The stator according to claim 8, wherein the tooth comprises: the tooth body; and a collar part integrally formed with a tooth tip part of the tooth body on a side opposite to the core body and extending in the circumferential direction; wherein the outer wall part comprises a pull-out slit formed for each of the teeth for pulling out the coil from the radially inner side to the radially outer side of the outer wall part, and the pull-out slit is disposed on a side opposite to the pull-in slit across a circumferential center of the corresponding tooth body, and in an area between a first straight line passing through the circumferential center of the tooth body and a radial center of the core body and a second straight line passing through a circumferential end of the collar part and the radial center of the core body.

10. An electric motor comprising: the stator according to claim 8; and a rotor rotatably disposed radially inward of the stator.