

DESCRIPTION

TITLE OF INVENTION: A 48-SLOT 8-POLE FLAT-WIRE WINDING STATOR AND FLAT-WIRE MOTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

The application is based on and claims priorities to Chinese Patent Application No. 202410701007.X, filed on May 31, 2024, entitled “A 48-SLOT 8-POLE FLAT-WIRE WINDING STATOR AND FLAT-WIRE MOTOR”, and Chinese Patent Application No. 202310637716.1, filed on May 31, 2023, entitled “A control method and a control system for a DC-coupled hydrogen generation power supply apparatus, and the power supply apparatus”, which are incorporated herein by reference in its entirety, as one part of the application.

TECHNICAL FIELD

The present invention belongs to the technical field of motors, and in particular to a 48-slot 8-pole flat-wire winding stator and a flat-wire motor.

BACKGROUND

With the rapid development of new energy vehicle technology, a drive motor, as one of the key actuating components of electric vehicles, is subject to increasingly high performance requirements. Currently, high speed, lightweight, and high efficiency have become the development trend for drive motors, resulting in high requirements for power density, high-efficiency range, and heat dissipation capability of the motor.

Winding stators may be divided into round-wire and flat-wire types. The difference between flat-wire motors and round-wire motors lies in the forming method of copper wires. The flat-wire is beneficial for improving the slot fill factor of the motor. Generally, the slot fill factor of round-wire motors is about 50%, while the slot fill factor of flat-wire motors can reach over 70%. An increase in slot fill factor means that more copper may be filled under the condition of unchanged space, resulting in reduced motor resistance and decreased copper loss at the same current. Compared with round-wire motors, copper conductors within slots of flat-wire motors have a larger contact area, with a better heat dissipation effect.

When the motor operates at a high speed, the alternating copper loss of the motor increases significantly. To reduce the copper loss, the number of conductor layers per stator slot is

generally increased, such as four layers, six layers, eight layers, etc. Since the conductors of each parallel branch are distributed at different positions within the stator slots, if the branches are asymmetric, this will result in significant differences in back electromotive force, resistance, and inductance, thereby causing circulating currents, increased additional losses, and reduced efficiency, while also leading to local overheating of motor windings and shortening the service life of the motor.

With different numbers of flat-wire winding slots and pole pairs, the wiring method of the winding structure also varies. For example, the 48-slot 8-pole configuration mostly adopts two-branch or four-branch schemes, while three-branch and six-branch schemes are less common or asymmetric. Due to limitations in the winding design structure, flexible conversion between different parallel branches cannot be achieved. Therefore, the existing design methods for flat-wire stator windings lack flexibility and adaptability, and cannot be tailored to design corresponding parallel branches as needed, resulting in certain limitations.

SUMMARY

To overcome the deficiencies in the prior art, the present invention is to provide a 48-slot 8-pole flat-wire winding stator and a flat-wire motor featuring a compact structure, simple manufacturing, symmetrical branches, and an orderly arrangement.

A 48-slot 8-pole flat-wire winding stator, comprising three-phase windings, wherein each of the phase windings comprises a plurality of groups of parallel winding branches, each group of winding branches comprises at least two branches, each of the branches comprises a plurality of coils sequentially arranged and connected in series in a circumferential core slot of a stator core, each of the branches comprises single coils and coils with a span of y , each of the branches takes a single coil positioned in an innermost layer of a slot opening of the core slot as a winding start, the single coil in the innermost layer of the slot opening serves as a neutral point lead-out wire, a stacked coil with a span of y is wound from a next innermost layer of the slot opening to an outermost layer of a slot bottom of the core slot, and a winding direction is commutated by any of the following methods:

Method 1: The stacked coil with a span of y is commutated in the outermost layer of the slot bottom in the same layer, then the stacked coil with a span of y is wound from a next outermost layer of the slot bottom to the innermost layer of the slot opening, and a stacked coil with a span of $y-1$ is commutated in the innermost layer of the slot opening in the same layer; and

Method 2: A concentric coil with a span of y is commutated in the outermost layer of the

slot bottom in the same layer, and then the stacked coil with a span of y is wound from a next outermost layer of the slot bottom to the innermost layer of the slot opening.

In some embodiments of the present invention, each group of winding branches comprises three branches, in the same layer of core slot, coils of the same branch are arranged in adjacent core slots, and a difference between adjacent coils is a ratio of the total number of the core slots to the total number of the branches.

In some embodiments of the present invention, each group of winding branches comprises two branches, the two branches have the same winding method, and the two branches are alternately arranged in adjacent core slots.

In some embodiments of the present invention, the stacked coil with a span of y comprises a first coil, the first coil is wound from the next innermost layer of the slot opening to the next outermost layer of the slot bottom, the first coil comprises a first coil body and first bent portions, the first coil body comprises two first support rods arranged in parallel and a first head connecting one ends of the two first support rods, the other ends of the two first support rods are provided with the first bent portions to form welding ends, the first bent portions are bent along a width direction of the first coil body and in a direction away from the first coil body.

In some embodiments of the present invention, the stacked coil with a span of y further comprises a second coil, the second coil is commutated in the outermost layer of the slot bottom in the same layer, the second coil comprises a second coil body and second bent portions, the second coil body comprises two second support rods arranged in parallel and a second head connecting one ends of the two second support rods, the other ends of the two second support rods are provided with the second bent portions to form welding ends, and the second bent portions are bent along one side of the second coil body along a width direction.

In some embodiments of the present invention, the single coil comprises a third coil, the third coil is disposed in the innermost layer of the slot opening as the neutral point lead-out wire, the third coil comprises a third coil body and a third bent portion, the third coil body comprises a third support rod, both ends of the third support rod are respectively provided with a third head portion and the third bent portion, and the third bent portion forms a welding end; and a bending direction of the third head portion is opposite to a bending direction of the third bent portion.

In some embodiments of the present invention, the concentric coil with a span of y comprises a fourth coil, the fourth coil is commutated in the outermost layer of the slot bottom in the same layer, the fourth coil comprises a fourth coil body and a fourth bent portion, the

fourth coil body comprises two fourth support rods arranged in parallel and a fourth head portion connecting one ends of the two fourth support rods, the other ends of the two fourth support rods are provided with the fourth bent portions to form welding ends, and the fourth bent portions are bent along one side of the fourth coil body along a width direction.

In some embodiments of the present invention, each of the phase windings comprises a group of winding branches, a first branch in the winding branches comprises a single coil A0, coils a1-A2, a3-A4, a5-A6, a7-A8, a9-A10, a11-A12, a13-A14, a15-A16, a17-A18, a19-A20, a21-A22, a23-A24, a25-A26, a27-A28, and a29-A30, and a single coil a31; a second branch in the winding branches comprises a single coil B0, coils b1-B2, b3-B4, b5-B6, b7-B8, b9-B10, b11-B12, b13-B14, b15-B16, b17-B18, b19-B20, b21-B22, b23-B24, b25-B26, b27-B28, and b29-B30, and a single coil b31; a third branch in the winding branches comprises a single coil C0, coils c1-C2, c3-C4, c5-C6, c7-C8, c9-C10, c11-C12, c13-C14, c15-C16, c17-C18, c19-C20, c21-C22, c23-C24, c25-C26, c27-C28, and c29-C30, and a single coil c31;

the single coil A0, the single coil B0, and the single coil C0 are all located in a first layer of the core slot along the slot opening toward the slot bottom, serving as winding starts; the single coil a31, the single coil b31, and the single coil c31 are all located in the first layer of the core slot from the slot opening toward the slot bottom, serving as the neutral point lead-out wires;

a1-A2 and a17-A18 both have the span of y, with upper layer sides thereof located in a second layer of the core slot, and lower layer sides thereof located in the first layer of the core slot;

a3-A4 and a19-A20 both have the span of y, with upper layer sides thereof located in the second layer of the core slot, and lower layer sides thereof located in a third layer of the core slot;

a5-A6 and a21-A22 both have the span of y, with upper layer sides thereof located in a fourth layer of the core slot, and lower layer sides thereof located in a fifth layer of the core slot;

a7-A8 and a23-A24 both have the span of y, with upper layer sides and lower layer sides thereof both located in a sixth layer of the core slot;

a9-A10 and a25-A26 both have the span of y, with upper layer sides thereof located in the fifth layer of the core slot, and lower layer sides thereof located in the fourth layer of the core slot;

a11-A12 and a27-A28 both have the span of y, with upper layer sides thereof located in the third layer of the core slot, and lower layer sides thereof located in the second layer of the

core slot ;

a13-A14 and a29-A30 both have the span of y , with upper layer sides thereof located in the first layer of the core slot , and lower layer sides thereof located in the second layer of the core slot ;

a15-A16 has the span of $y-1$, with an upper layer side and a lower layer side thereof both located in the first layer of the core slot ;

b1-B2 and b17-B18 both have the span of y , with upper layer sides thereof located in the second layer of the core slot , and lower layer sides thereof located in the third layer of the core slot ;

b3-B4 and b19-B20 both have the span of y , with upper layer sides thereof located in the fourth layer of the core slot , and lower layer sides thereof located in the third layer of the core slot ;

b5-B6 and b21-B22 both have the span of y , with upper layer sides thereof located in the fourth layer of the core slot , and lower layer sides thereof located in the fifth layer of the core slot ;

b7-B8 and b23-B24 both have the span of y , with upper layer sides and lower layer sides thereof both located in the sixth layer of the core slot ;

b9-B10 and b25-B26 both have the span of y , with upper layer sides thereof located in the fifth layer of the core slot , and lower layer sides thereof located in the fourth layer of the core slot ;

b11-B12 and b27-B28 both have the span of y , with upper layer sides thereof located in the third layer of the core slot , and lower layer sides thereof located in the fourth layer of the core slot ;

b13-B14 and b29-B30 both have the span of y , with upper layer sides thereof located in the third layer of the core slot , and lower layer sides thereof located in the second layer of the core slot ;

b15-B16 has the span of $y-1$, with an upper layer side and a lower layer side thereof both located in the first layer of the core slot ;

c1-C2 and c17-C18 both have the span of y , with upper layer sides thereof located in the second layer of the core slot , and lower layer sides thereof located in the third layer of the core slot ;

c3-C4 and c19-C20 both have the span of y , with upper layer sides thereof located in the fourth layer of the core slot , and lower layer sides thereof located in the fifth layer of the core slot ;

c5-C6 and c21-C22 both have the span of y, with upper layer sides thereof located in the sixth layer of the core slot , and lower layer sides thereof located in the fifth layer of the core slot ;

c7-C8 and c23-C24 both have the span of y, with upper layer sides and lower layer sides thereof both located in the sixth layer of the core slot ;

c9-C10 and c25-C26 both have the span of y, with upper layer sides thereof located in the fifth layer of the core slot , and lower layer sides thereof located in the sixth layer of the core slot ;

c11-C12 and c27-C28 both have the span of y, with upper layer sides thereof located in the fifth layer of the core slot , and lower layer sides thereof located in the fourth layer of the core slot ;

c13-C14 and c29-C30 both have the span of y, with upper layer sides thereof located in the third layer of the core slot , and lower layer sides thereof located in the second layer of the core slot ;

c15-C16 has the span of y-1, with an upper layer side and a lower layer side thereof both located in the first layer of the core slot ;

in the first branch of the windings, the coil A0 is connected to the coil a1-A2 through twisted-head welding, the coil a1-A2 is connected to the coil a3-A4 through twisted-head welding, the coil a3-A4 is connected to the coil a5-A6 through twisted-head welding, the coil a5-A6 is connected to the coil a7-A8 through twisted-head welding, and so on; a coil sequence goes from the first layer to the second layer, the second layer to the third layer, the third layer to the fourth layer, and the fourth layer to the fifth layer; after completing the same-layer winding in the sixth layer, the coil returns to the fifth layer, then goes to the fourth layer, further to the third layer, then to the second layer, and finally to the first layer; this cycle is repeated to complete the winding of the winding branches; the second branch and the third branch are similar to the first branch; and the winding is commutated through the coils in the same layer in the outermost layer of the slot bottom and the innermost layer of the slot opening, such that the three-phase windings are symmetrical.

In some embodiments of the present invention, each of the phase windings comprises a group of winding branches, one branch in the winding branches comprises a single coil A0, coils a1-A2, a3-A4, a5-A6, a7-A8, a9-A10, a11-A12, a13-A14, a15-A16, a17-A18, a19-A20, a21-A22, a23-A24, a25-A26, a27-A28, a29-A30, a31-A32, a33-A34, a35-A36, a37-A38, a39-A40, a41-A42, a43-A44, a45-A46, and a47; another branch comprises a single coil B0, coils b1-B2, b3-B4, b5-B6, b7-B8, b9-B10, b11-B12, b13-B14, b15-B16, b17-B18, b19-B20, b21-

B22, b23-B24, b25-B26, b27-B28, b29-B30, b31-B32, b33-B34, b35-B36, b37-B38, b39-B40, b41-B42, b43-B44, b45-B46, and b47;

the two branches have the same winding method, the single coil A0 and the single coil B0 are both located in the first layer of the core slot from the slot opening toward the slot bottom, serving as winding starts; the single coil a47 and the single coil b47 are both located in the first layer of the core slot from the slot opening toward the slot bottom, serving as neutral point lead-out wires;

a1-A2, a3-A4, a5-A6, a40-A41, b1-B2, b3-B4, b5-B6, and b40-B41 all have the span of y, with upper layer sides thereof located in a second layer of the core slot, and lower layer sides thereof located in the first layer of the core slot;

a7-A8 and b7-B8 both have the span of y, with upper layer sides thereof located in the second layer of the core slot, and lower layer sides thereof located in a third layer of the core slot;

a9-A10, a11-A12, a13-A14, b9-B10, b11-B12, and b13-B14 all have the span of y, with upper layer sides thereof located in a fourth layer of the core slot, and lower layer sides thereof located in the third layer of the core slot;

a15-A16 and b15-B16 both have the span of y, with upper layer sides thereof located in the fourth layer of the core slot, and lower layer sides thereof located in a fifth layer of the core slot;

a17-A18, a19-A20, a21-A22, b17-B18, b19-B20, and b21-B22 all have the span of y, with upper layer sides thereof located in a sixth layer of the core slot, and lower layer sides thereof located in the fifth layer of the core slot;

a23-A24 and b23-B24 both have the span of y, with upper layer sides and lower layer sides thereof both located in the sixth layer of the core slot;

a25-A26, a27-A28, a29-A30, b25-B26, b27-B28, and b29-B30 all have the span of y, with upper layer sides thereof located in the fifth layer of the core slot, and lower layer sides thereof located in the sixth layer of the core slot;

a31-A32 and b31-B32 both have the span of y, with upper layer sides thereof located in the fifth layer of the core slot, and lower layer sides thereof located in the fourth layer of the core slot;

a33-A34, a35-A36, a37-A38, b33-B34, b35-B36, and b37-B38 all have the span of y, with upper layer sides thereof located in the third layer of the core slot, and lower layer sides thereof located in the fourth layer of the core slot;

a39-A40 and b39-B40 both have the span of y, with upper layer sides thereof located in

the third layer of the core slot , and lower layer sides thereof located in the second layer of the core slot ;

a41-A42, a43-A44, a45-A46, b41-B42, b43-B44, and b45-B46 all have the span of y, with upper layer sides thereof located in the first layer of the core slot , and lower layer sides thereof located in the second layer of the core slot ;

in the first branch, the coil A0 is connected to the coil a1-A2 through twisted-head welding, the coil a1-A2 is connected to the coil a3-A4 through twisted-head welding, the coil a3-A4 is connected to the coil a5-A6 through twisted-head welding, the coil a5-A6 is connected to the coil a7-A8 through twisted-head welding, and so on; a coil connection sequence starts from the first layer and the second layer, transitions to the third layer and the fourth layer, further transitions to the fifth layer and the sixth layer, finally realizes same-layer crossover in the sixth layer through the concentric coil, and then the coils are sequentially connected to the first layer; this cycle is repeated to complete the winding of the first branch, and the winding of the second branch follows the same rule, by parity of reasoning; and the winding is commutated through the outermost layer of the slot bottom, such that the three-phase windings are symmetrical.

As a general technical concept, the present invention further provides a flat-wire motor including the aforementioned 48-slot 8-pole flat-wire winding stator.

Compared with the prior art, the present invention has the following advantages:

1. In the 48-slot 8-pole flat-wire winding stator of the present invention, a winding arrangement is adopted in each group of winding branches by combining coils with different spans and different types. A certain wire type is used to replace several coils in a specific layer of the phase winding, while other wire types remain unchanged and the welding ends are consistent, thereby achieving different branch connection schemes. Flexible conversion of different numbers of parallel branches can be realized as needed. Through connection schemes and Busbar connections, different branch schemes such as 1, 2, 3, and 6 branches for the 48-slot stator can be achieved, thereby maximizing compatibility with different branch schemes with minimal modification. At the same time, the number of wire types is decreased and the complexity of the manufacturing process is lowered, facilitating production and eliminating a series of problems caused by branch asymmetry. This ensures that each of the branches is symmetrical both in the slot and in the layer, i.e., each parallel branch is distributed in a ring-symmetrical structure within the core slots, thereby achieving uniform and symmetrical distribution of each phase winding, resulting in balanced branch potential, no circulating current, and harmonic cancellation, which greatly improves the motor performance. The

present invention not only solves a series of problems caused by branch asymmetry, but also effectively reduces the manufacturing difficulty and high cost of flat-wire winding processes resulting from increased phase numbers, thereby effectively reducing vehicle manufacturing costs.

2. In the winding stator and flat-wire motor of the present invention, the winding compatible with different branch schemes is achieved without changing the welding ends, allowing the flexible conversion of different numbers of parallel branches as needed, while reducing the manufacturing difficulty. Coils with different spans are used to form transposed windings for transposition, ensuring complete symmetry among the branches, avoiding circulating currents, and reducing motor temperature rise. The flat-wire conductors within the same core slot of the winding stator belong to the same phase, and no inter-phase insulation is required between conductors within the slot, thereby reducing the manufacturing difficulty and motor insulation cost.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram illustrating a structural principle of a first coil in a specific embodiment of the present invention.

FIG. 2 is a schematic diagram illustrating a structural principle of a second coil in a specific embodiment of the present invention.

FIG. 3 is a schematic diagram illustrating a structural principle of a third coil in a specific embodiment of the present invention.

FIG. 4 is a schematic diagram illustrating a structural principle of a fourth coil in a specific embodiment of the present invention.

FIG. 5 is a schematic diagram illustrating a structural principle of a stator gate-shaped end in Embodiment 1 of the present invention.

FIG. 6 is a schematic diagram illustrating a structural principle of a stator welding end in Embodiment 1 of the present invention.

FIG. 7 is a schematic diagram illustrating a phase arrangement of any phase winding in Embodiment 1 of the present invention.

FIG. 8 is a schematic diagram illustrating a star connection of three-phase windings in Embodiment 1 of the present invention.

FIG. 9 is a schematic diagram illustrating a delta connection of the three-phase windings in Embodiment 1 of the present invention.

FIG. 10 is a schematic diagram illustrating a structural principle of a stator gate-shaped end in Embodiment 2 of the present invention.

FIG. 11 is a schematic diagram illustrating a structural principle of a stator welding end in Embodiment 2 of the present invention.

FIG. 12 is a schematic diagram illustrating a phase arrangement of any phase winding in Embodiment 2 of the present invention.

FIG. 13 is a schematic diagram illustrating a star connection of three-phase windings in Embodiment 2 of the present invention.

FIG. 14 is a schematic diagram illustrating a delta connection of the three-phase windings in Embodiment 2 of the present invention.

Description of reference signs: 1, first coil; 11, first coil body; 111, first support rod; 112, first head; 12, first bent portion; 2, second coil; 21, second coil body; 211, second support rod; 212, second head; 22, second bent portion; 3, third coil; 31, third coil body; 311, third support rod; 312, third head; 32, third bent portion; 4, fourth coil; 41, fourth coil body; 411, fourth support rod; 412, fourth head; 42, fourth bent portion; 5, stator core; 51, core slot.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The present invention will be further described below in conjunction with the drawings of the specification and specific preferred embodiments, but the scope of protection of the present invention is not limited thereby.

Embodiment 1

As shown in FIGS. 1 to 3 and FIGS. 5 to 9, the winding stator in this embodiment includes three-phase windings, where each of the phase windings includes a plurality of groups of parallel winding branches, each group of winding branches includes three branches, and each of the branches includes a plurality of coils arranged sequentially and connected in series in a circumferential core slot 51 of the stator core 5. Each of the branches includes single coils and coils with a span of y . Each of the branches takes a single coil positioned in an innermost layer of a slot opening of the core slot 51 as a winding start (the first layer from the slot opening to the slot bottom), using the single coil as a neutral point lead-out wire. The stacked coils with a

span of y are wound from a next inner layer of the slot opening of the core slot 51 to an outermost layer of the slot bottom (the last layer from the slot opening to the slot bottom), and the stacked coils with a span of y are commutated in the same layer in the outermost layer of the slot bottom. Then, the stacked coils with a span of y are wound from the next outer layer of the slot bottom to the innermost layer of the slot opening, and the stacked coils with a span of $y-1$ are commutated in the same layer in the innermost layer of the slot opening. This cycle is repeated to achieve branch symmetry.

Furthermore, among the three branches of each group of winding branches, in the same layer of core slot 51, coils of the same branch are arranged in adjacent core slots 51, and a difference between adjacent coils is a ratio of the total number of the core slots 51 to the total number of the branches. For example, if the total number of core slots 51 is 48 and the total number of branches in each group of windings is 3, in the first layer of core slots 51, the coil in the first core slot 51 is labeled as 1, and the coil in the second core slot 51 is labeled as 17. By arranging the branches at equal intervals, branch symmetry is achieved.

As shown in FIG. 1, in this embodiment, the stacked coil with a span of y includes a first coil 1, the first coil 1 is wound from the next innermost layer of the slot opening to the next outermost layer of the slot bottom, the first coil 1 includes a first coil body 11 and first bent portions 12, the first coil body 11 includes two first support rods 111 arranged in parallel and a first head 112 connecting one ends of the two first support rods 111, the other ends of the two first support rods 111 are provided with the first bent portions 12 to form welding ends, the first bent portions 12 are bent along a width direction of the first coil body 11 and in a direction away from the first coil body 11.

As shown in FIG. 2, in this embodiment, the stacked coil with a span of y further includes a second coil 2, the second coil 2 is commutated in the outermost layer of the slot bottom in the same layer, the second coil 2 includes a second coil body 21 and second bent portions 22, the second coil body 21 includes two second support rods 211 arranged in parallel and a second head 212 connecting one ends of the two second support rods 211, the other ends of the two second support rods 211 are provided with the second bent portions 22 to form welding ends, and the second bent portions 22 are bent along one side of the second coil body 21 along the width direction.

As shown in FIG. 3, in this embodiment, the single coil includes a third coil 3, the third coil 3 is disposed in the innermost layer of the slot opening as the neutral point lead-out wire,

the third coil 3 includes a third coil body 31 and a third bent portion 32, the third coil body 31 includes a third support rod 311, both ends of the third support rod 311 are respectively provided with a third head portion 312 and the third bent portion 32, and the third bent portion 32 forms a welding end; and a bending direction of the third head portion 312 is opposite to a bending direction of the third bent portion 32.

In this embodiment, the coils in each group of winding branches are wound in the direction from inside to outside, each of the coils has the same span, and the upper layer side and the lower layer side of the coils are respectively located in the core slots 51 of adjacent layers. The coils are commutated in the same layer in the outermost layer of the slot bottom and the innermost layer of the slot opening to eliminate phase differences between different branches, ensuring that each of the branches is symmetrical both in the slot and in the layer, i.e., each parallel branch is distributed in a ring-symmetrical structure within the core slots, thereby achieving uniform and symmetrical distribution of each of the phase windings, resulting in balanced branch potential, no circulating current, and harmonic cancellation, which greatly improves the motor performance. Moreover, the flat-wire conductors in the same core slot of the winding stator belong to the same phase, and no inter-phase insulation is required between the conductors within the slot, thereby reducing the manufacturing difficulty and the motor insulation cost.

In this embodiment, heads of the first coil 1 and the second coil 2 are both V-shaped or arc-shaped. The coil with the V-shaped head is referred to as a V-shaped coil, and the coil with the arc-shaped head is referred to as a U-shaped coil. In this embodiment, each of the coils may be a U-shaped coil or a V-shaped coil. Since all the coils adopt the same shape, special-shaped coils and crossover coils are eliminated, thereby facilitating assembly and mass production. Of course, in other embodiments, a combination of U-shaped coils and V-shaped coils may also be adopted.

As shown in FIGS. 8 and 9, in this embodiment, the parallel connection between branches in each group of winding branches is either a star connection or a delta connection. Specifically, the three-phase windings may be connected in star or delta configuration via Busbars or lead-out wires.

In this embodiment, the neutral points of the coils (such as a31, b31, and c31 in FIG. 7) are connected via the Busbars. The structure is simple, and the height is comparable to that of the welding end, reducing the height of the winding end and thus reducing the motor volume.

Specifically, taking a 48-slot 8-pole 6-layer flat-wire winding with three branches as an example, the stator gate-shaped end and welding end of the motor are shown in FIGS. 5 and 6, respectively. The neutral point of the motor is connected via the Busbar, which is structurally simple. The number of the coil layers increases sequentially from the slot opening to the slot bottom. U-phase branch 1: A-a, branch 2: B-b, branch 3: C-c; since the number of slots per pole per phase is 2 and the number of branches is 3, to achieve branch symmetry, the first layer uses I-shaped lead-out coils, and the first and second layers, second and third layers, third and fourth layers, fourth and fifth layers use U-shaped coils with the same span, and the sixth layer uses U-shaped coils with the same span. The three branches of the U-phase winding are denoted as A, B, and C, respectively. a1-A2, a3-A4, a5-A6 constitute the U-shaped coils, and other branches are arranged similarly.

Specifically, the first layer uses a single lead-out coil, the first to second layers, second to third layers, third to fourth layers, fourth to fifth layers, and fifth to sixth layers all use the U-shaped coils with a span of 6, and the sixth layer uses a combination of the U-shaped coils with a span of 6 in the same layer.

Each of the phase windings includes a group of winding branches, a first branch in the winding branches includes a single coil A0, coils a1-A2, a3-A4, a5-A6, a7-A8, a9-A10, a11-A12, a13-A14, a15-A16, a17-A18, a19-A20, a21-A22, a23-A24, a25-A26, a27-A28, and a29-A30, and a single coil a31; a second branch in the winding branches includes a single coil B0, coils b1-B2, b3-B4, b5-B6, b7-B8, b9-B10, b11-B12, b13-B14, b15-B16, b17-B18, b19-B20, b21-B22, b23-B24, b25-B26, b27-B28, and b29-B30, and a single coil b31; a third branch in the winding branches includes a single coil C0, coils c1-C2, c3-C4, c5-C6, c7-C8, c9-C10, c11-C12, c13-C14, c15-C16, c17-C18, c19-C20, c21-C22, c23-C24, c25-C26, c27-C28, and c29-C30, and a single coil c31; and the arrangement of each of the phase windings is shown in FIG. 12.

The single coil A0, the single coil B0, and the single coil C0 are all located in a first layer of the core slot 51 along the slot opening toward the slot bottom, serving as winding starts, and have the shape of the single coil shown in FIG. 3. The single coil a31, the single coil b31, and the single coil c31 are all located in the first layer of the core slot 51 from the slot opening toward the slot bottom, serving as the neutral point lead-out wires, and have the shape of the single coil shown in FIG. 3. The lead-out wires exit from the gate-shaped end. The welding end is cut flat, welded, and coated through a simple process, with no additional treatment

required.

a1-A2 and a17-A18 both have the span of 6, with upper layer sides thereof located in a second layer of the core slot 51, and lower layer sides thereof located in the first layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a3-A4 and a19-A20 both have the span of 6, with upper layer sides thereof located in the second layer of the core slot 51, and lower layer sides thereof located in a third layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a5-A6 and a21-A22 both have the span of 6, with upper layer sides thereof located in a fourth layer of the core slot 51, and lower layer sides thereof located in a fifth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a7-A8 and a23-A24 both have the span of 6, with upper layer sides and lower layer sides thereof both located in a sixth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 2.

a9-A10 and a25-A26 both have the span of 6, with upper layer sides thereof located in the fifth layer of the core slot 51, and lower layer sides thereof located in the fourth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a11-A12 and a27-A28 both have the span of 6, with upper layer sides thereof located in the third layer of the core slot 51, and lower layer sides thereof located in the second layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a13-A14 and a29-A30 both have the span of 6, with upper layer sides thereof located in the first layer of the core slot 51, and lower layer sides thereof located in the second layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a15-A16 has the span of 5, with an upper layer side and a lower layer side thereof both located in the first layer of the core slot 51, and is connected through a copper Busbar or a coil.

b1-B2 and b17-B18 both have the span of 6, with upper layer sides thereof located in the second layer of the core slot 51, and lower layer sides thereof located in a third layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

b3-B4 and b19-B20 both have the span of 6, with upper layer sides thereof located in the fourth layer of the core slot 51, and lower layer sides thereof located in the third layer of the core slot 51; the shape is the stacked U-shaped coil shown in FIG. 1.

b5-B6 and b21-B22 both have the span of 6, with upper layer sides thereof located in a fourth layer of the core slot 51, and lower layer sides thereof located in a fifth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

b7-B8 and b23-B24 both have the span of 6, with upper layer sides and lower layer sides thereof both located in a sixth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 2.

b9-B10 and b25-B26 both have the span of 6, with upper layer sides thereof located in the fifth layer of the core slot 51, and lower layer sides thereof located in the fourth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

b11-B12 and b27-B28 both have the span of 6, with upper layer sides thereof located in the third layer of the core slot 51, and lower layer sides thereof located in the fourth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

b13-B14 and b29-B30 both have the span of 6, with upper layer sides thereof located in the third layer of the core slot 51, and lower layer sides thereof located in the second layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

b15-B16 has the span of 5, with an upper layer side and a lower layer side thereof both located in the first layer of the core slot 51, and is connected through a copper Busbar or a coil.

c1-C2 and c17-C18 both have the span of 6, with upper layer sides thereof located in the second layer of the core slot 51, and lower layer sides thereof located in a third layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

c3-C4 and c19-C20 both have the span of 6, with upper layer sides thereof located in a fourth layer of the core slot 51, and lower layer sides thereof located in a fifth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

c5-C6 and c21-C22 both have the span of 6, with upper layer sides thereof located in the sixth layer of the core slot 51, and lower layer sides thereof located in the fifth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

c7-C8 and c23-C24 both have the span of 6, with upper layer sides and lower layer sides thereof both located in a sixth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 2.

c9-C10 and c25-C26 both have the span of 6, with upper layer sides thereof located in the

fifth layer of the core slot 51, and lower layer sides thereof located in the sixth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

c11-C12 and c27-C28 both have the span of 6, with upper layer sides thereof located in the fifth layer of the core slot 51, and lower layer sides thereof located in the fourth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

c13-C14 and c29-C30 both have the span of 6, with upper layer sides thereof located in the third layer of the core slot 51, and lower layer sides thereof located in the second layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

c15-C16 has the span of 5, with an upper layer side and a lower layer side thereof both located in the first layer of the core slot 51, and is connected by a copper Busbar or a coil.

In the first branch of the windings, the coil A0 is connected to the coil a1-A2 through twisted-head welding, the coil a1-A2 is connected to the coil a3-A4 through twisted-head welding, the coil a3-A4 is connected to the coil a5-A6 through twisted-head welding, the coil a5-A6 is connected to the coil a7-A8 through twisted-head welding, and so on; a coil sequence goes from the first layer to the second layer, the second layer to the third layer, the third layer to the fourth layer, and the fourth layer to the fifth layer; after the same-layer winding in the sixth layer is completed, the coil returns to the fifth layer, then goes to the fourth layer, further to the third layer, then to the second layer, and finally to the first layer; this cycle is repeated to complete the winding of the winding branches; the second branch and the third branch are similar to the first branch; and the winding is commutated through the coils in the same layer in the outermost layer of the slot bottom and the innermost layer of the slot opening, such that the three-phase windings are symmetrical.

In this embodiment, coils are commutated by the coils in the same layer to eliminate phase differences between different branches and ensure complete symmetry of each of the branches. This embodiment fully considers manufacturability. The coils are composed of U-shaped coils and single wires, reducing the variety of the U-shaped coils. Most parts use interlayer wires, which lowers the manufacturing difficulty and facilitates the mass production. In other embodiments, Bus-bar commutation may also be adopted.

In this embodiment, the stator winding consists of three types of coils, as shown in FIGS. 1 to 3. The flat-wire stator and motor fully consider manufacturability. The coils are composed of U-shaped coils and a single type of wire, reducing the variety of U-shaped coils and lowering

the manufacturing difficulty and facilitating the mass production. The windings are commutated by the coils in the same layer in the innermost and outermost layers, ensuring complete symmetry of the three-phase windings, reducing wire types, eliminating irregular wires, and greatly reducing the complexity of winding formation. Only twisted welding at the winding end is required for connection, which is convenient for production and can eliminate a series of problems caused by branch asymmetry. The three-phase windings may be connected in star or delta configuration via Busbars or lead-out wires, resulting in a compact structure.

As shown in FIG. 5 and FIG. 6, this embodiment further provides a stator, which includes a stator core 5 and the aforementioned stator winding. 48 core slots 51 are circumferentially disposed on an inner wall of the stator core 5, part of the phase windings in the winding stator is wound inside the core slots 51, and part of the phase windings is located outside the core slots 51. Each of the core slots 51 contains six layers of phase windings of the same phase, and the number of layers of phase windings in each of the core slots 51 is identical. It may be understood that in practical applications, the number of winding layers in each of the stator slots includes but is not limited to six layers, and may also be two layers, or four layers, or eight layers, or the like. The winding method may refer to the aforementioned six-layer winding method.

This embodiment further provides a flat-wire motor including the aforementioned winding stator, which may be applied to vehicles such as electric vehicles (EV), pure electric vehicles (PEV/BEV), hybrid electric vehicles (HEV), range-extended electric vehicles (REEV), plug-in hybrid electric vehicles (PHEV), and new energy vehicles (NEV). In the flat-wire wave winding stator of this embodiment, the flat-wire wave winding stator does not require welding and has no weld points. Furthermore, it offers high design flexibility, reduces the processing steps of the flat-wire wave winding stator, simplifies the process, and lowers the cost.

This embodiment further provides a vehicle including the aforementioned motor, which may be an electric vehicle (EV), a pure electric vehicle (PEV/BEV), a hybrid electric vehicle (HEV), a range-extended electric vehicle (REEV), a plug-in hybrid electric vehicle (PHEV), or a new energy vehicle (NEV).

In this embodiment, the motor is composed of three types of coils. The windings are commutated by the coils in the same layer in the innermost layer and the outermost layer to eliminate phase differences between different branches and ensure complete symmetry of each of the branches.

Embodiment 2

As shown in FIGS. 1, 3, 4, and FIGS. 10 to 14, the winding stator of this embodiment has a similar structural arrangement and operating principle to the winding stator in Embodiment 1. The two identical same-layer coils with a span of 6 in the sixth layer of Embodiment 1 are replaced with same-layer concentric coils, the other wire types remain unchanged, the welding ends remain unchanged, and the coils are rearranged and the quantity of each wire type is changed, thereby forming a flat-wire winding with 48 slots, 6 layers, 8 poles, and 2 branches.

Specifically, the winding stator includes three-phase phase windings. Each of the phase windings includes a plurality of groups of parallel winding branches. The group of the winding branches includes two branches. Each of the branches includes a plurality of coils sequentially arranged and serially connected on a circumferential core slot 51 of a stator core 5. Each of the branches includes single coils and coils with a span of y , each of the branches takes a single coil positioned in an innermost layer of a slot opening of the core slot 51 as a winding start, the single coil in the innermost layer (the first layer from the slot opening to the slot bottom) of the slot opening serves as a neutral point lead-out wire, a stacked coil with a span of y is wound from a next innermost layer of the slot opening to the outermost layer (the last layer from the slot opening to the slot bottom) of a slot bottom of the core slot 51, a concentric coil with a span of y is commutated in the outermost layer of the slot bottom in the same layer, then the stacked coil with a span of y is wound from the next outermost layer of the slot bottom to the innermost layer of the slot opening. This cycle is repeated to achieve branch symmetry.

Further, the two branches have the same winding method and are alternately arranged in adjacent core slots 51.

As shown in FIG. 4, in this embodiment, the concentric coil with a span of y includes a fourth coil 4, the fourth coil 4 is commutated in the same layer in the outermost layer of the slot bottom, the fourth coil 4 includes a fourth coil body 41 and fourth bent portions 42, the fourth coil body 41 includes two fourth support rods 411 arranged in parallel and a fourth head portion 412 connecting one ends of the two fourth support rods 411, the other ends of the two fourth support rods 411 are provided with the fourth bent portions 42 to form welding ends, the fourth bent portions 42 are bent along one side of the fourth coil body 41 along the width direction .

As shown in FIGS. 13 and 14, in this embodiment, the parallel connection between branches in each group of winding branches is either a star connection or a delta connection.

Specifically, the three-phase windings may be connected in star or delta configuration via Busbars or lead-out wires.

Specifically, taking 48-slot 8-pole six-layer flat-wire winding with two branches as an example, the stator gate-shaped end and welding end of the motor are shown in FIGS. 10 and 11, respectively. The motor neutral point is connected via the Busbar, which is structurally simple. The number of the coil layers increases sequentially from the slot opening to the slot bottom. U-phase branch: A-a, B-b. Since the number of slots per pole per phase is 2 and the number of branches is 2, to achieve branch symmetry, the first layer uses a single lead coil. The first to second layers, the second to third layers, the third to fourth layers, the fourth to fifth layers, and the fifth to sixth layers, all use U-shaped coils with a span of 6. The sixth layer uses same-layer concentric U-shaped coils with a span of 6. The U-phase winding branch is denoted as A; a1-A2, a3-A4, a5-A6 constitute the U-shaped coil, denoted as B; b1-B2, b3-B4, b5-B6 constitute the U-shaped coils, and so on.

Each of the phase windings includes a group of winding branches, one branch in the winding branches includes a single coil A0, coils a1-A2, a3-A4, a5-A6, a7-A8, a9-A10, a11-A12, a13-A14, a15-A16, a17-A18, a19-A20, a21-A22, a23-A24, a25-A26, a27-A28, a29-A30, a31-A32, a33-A34, a35-A36, a37-A38, a39-A40, a41-A42, a43-A44, a45-A46, and a47; another branch includes a single coil B0, coils b1-B2, b3-B4, b5-B6, b7-B8, b9-B10, b11-B12, b13-B14, b15-B16, b17-B18, b19-B20, b21-B22, b23-B24, b25-B26, b27-B28, b29-B30, b31-B32, b33-B34, b35-B36, b37-B38, b39-B40, b41-B42, b43-B44, b45-B46, and b47; and the arrangement of the phase-windings is shown in FIG. 12.

The two branches have the same winding method. The single coil A0 and the single coil B0 are both located in the first layer in a direction of the slot bottom within the slot opening of the core slot 51 as the winding start; and the shape is the single coil shown in FIG. 3. The single coil a47 and the single coil b47 are both located in the first layer in a direction of the slot bottom within the slot opening of the core slot 51 as the neutral point lead-out wire; the lead-out wire exits from the gate-shaped end, and the welding end is cut flat, welded, and coated with a simple process, with no additional treatment required.

a1-A2, a3-A4, a5-A6, a40-A41, b1-B2, b3-B4, b5-B6, and b40-B41 have the span of y, with upper layer sides thereof located in the second layer of the core slot 51, and lower layer sides thereof located in the first layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a7-A8 and b7-B8 both have the span of 6, with upper layer sides thereof located in the second layer of the core slot 51, and lower layer sides thereof located in a third layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

The span of a9-A10, a11-A12, a13-A14, b9-B10, b11-B12, and b13-B14 is 6, with the upper layer sides thereof located in the fourth layer of the core slot 51 and the lower layer sides thereof located in the third layer of the core slot 51; the configuration is a stacked U-shaped coil as shown in FIG. 1.

a15-A16 and b15-B16 both have the span of 6, with upper layer sides thereof located in a fourth layer of the core slot 51, and lower layer sides thereof located in a fifth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a17-A18, a19-A20, a21-A22, b17-B18, b19-B20, and b21-B22 have the span of y , with upper layer sides thereof located in the sixth layer of the core slot 51, and lower layer sides thereof located in the fifth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a23-A24 and b23-B24 both have the span of 6, with upper layer sides and lower layer sides thereof both located in a sixth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 4.

a25-A26, a27-A28, a29-A30, b25-B26, b27-B28, and b29-B30 have the span of y , with upper layer sides thereof located in the fifth layer of the core slot 51, and lower layer sides thereof located in the sixth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a31-A32 and b31-B32 both have the span of 6, with upper layer sides thereof located in the fifth layer of the core slot 51, and lower layer sides thereof located in the fourth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a33-A34, a35-A36, a37-A38, b33-B34, b35-B36, and b37-B38 have the span of y , with upper layer sides thereof located in the third layer of the core slot 51, and lower layer sides thereof located in the fourth layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a39-A40 and b39-B40 both have the span of 6, with upper layer sides thereof located in the third layer of the core slot 51, and lower layer sides thereof located in the second layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

a41-A42, a43-A44, a45-A46, b41-B42, b43-B44, and b45-B46 have the span of y , with upper layer sides thereof located in the first layer of the core slot 51, and lower layer sides thereof located in the second layer of the core slot 51; and the shape is the stacked U-shaped coil shown in FIG. 1.

in the first branch, the coil A0 is connected to the coil a1-A2 through twisted-head welding, the coil a1-A2 is connected to the coil a3-A4 through twisted-head welding, the coil a3-A4 is connected to the coil a5-A6 through twisted-head welding, the coil a5-A6 is connected to the coil a7-A8 through twisted-head welding, and so on; a coil connection sequence starts from the first layer and the second layer, transitions to the third layer and the fourth layer, further transitions to the fifth layer and the sixth layer, finally realizes same-layer crossover in the sixth layer through the concentric coil, and then the coils are sequentially connected to the first layer; this cycle is repeated to complete the winding of the first branch, and the winding of the second branch follows the same rule, by parity of reasoning; and the winding is commutated through the outermost layer of the slot bottom, such that the three-phase windings are symmetrical. In this embodiment, with the welding end unchanged, windings compatible with different branch schemes are achieved, allowing flexible conversion of the number of parallel branches as needed, while reducing the manufacturing difficulty.

Although the present invention is disclosed as above in preferred embodiments, which are not intended to limit the present invention. Without departing from the spiritual essence and technical solutions of the present invention, any skilled person familiar with the art can make numerous possible variations and modifications to the technical solutions of the present invention, or amend these technical solutions into equivalent embodiments with equal changes, by using the methods and technical content disclosed above. Therefore, without departing from the contents of the technical solutions of the present invention, any simple alternations, equivalent substitutions, equivalent changes and modifications made to the embodiments above based on the technical essence of the present invention shall be construed as falling within the protection scope of the technical solutions of the present invention.

WHAT IS CLAIMED IS:

1. A 48-slot 8-pole flat-wire winding stator, characterized in that comprising three-phase phase windings, wherein each of the phase windings comprises a plurality of groups of parallel winding branches, each group of winding branches comprises at least two branches, each of the branches comprises a plurality of coils sequentially arranged and connected in series in a circumferential core slot (51) of a stator core (5), each of the branches comprises single coils and coils with a span of y , each of the branches takes a single coil positioned in an innermost layer of a slot opening of the core slot (51) as a winding start, the single coil in the innermost layer of the slot opening serves as a neutral point lead-out wire, a stacked coil with a span of y is wound from a next innermost layer of the slot opening to an outermost layer of a slot bottom of the core slot (51), and a winding direction is commutated by any of the following methods:

Method 1: The stacked coil with a span of y is commutated in the outermost layer of the slot bottom in the same layer, then the stacked coil with a span of y is wound from a next outermost layer of the slot bottom to the innermost layer of the slot opening, and a stacked coil with a span of $y-1$ is commutated in the innermost layer of the slot opening in the same layer; and

Method 2: A concentric coil with a span of y is commutated in the outermost layer of the slot bottom in the same layer, and then the stacked coil with a span of y is wound from a next outermost layer of the slot bottom to the innermost layer of the slot opening.

2. The 48-slot 8-pole flat-wire winding stator according to claim 1, characterized in that wherein each group of winding branches comprises three branches, in the same layer of core slot (51), coils of the same branch are arranged in adjacent core slots (51), and a difference between adjacent coils is a ratio of the total number of the core slots (51) to the total number of the branches.

3. The 48-slot 8-pole flat-wire winding stator according to claim 1, characterized in that wherein each group of winding branches comprises two branches, the two branches have the same winding method, and the two branches are alternately arranged in adjacent core slots (51).

4. The 48-slot 8-pole flat-wire winding stator according to claim 1, characterized in that wherein the stacked coil with a span of y comprises a first coil (1), the first coil (1) is wound from the next innermost layer of the slot opening to the next outermost layer of the slot bottom, the first coil (1) comprises a first coil body (11) and first bent portions (12), the first coil body (11) comprises two first support rods (111) arranged in parallel and a first head (112) connecting one ends of the two first support rods (111), the other ends of the two first support rods (111) are provided with the first bent portions (12) to form welding ends, the first bent portions (12)

are bent along a width direction of the first coil body (11) and in a direction away from the first coil body (11).

5. The 48-slot 8-pole flat-wire winding stator according to claim 1, characterized in that wherein the stacked coil with a span of y further comprises a second coil (2), the second coil (2) is commutated in the outermost layer of the slot bottom in the same layer, the second coil (2) comprises a second coil body (21) and second bent portions (22), the second coil body (21) comprises two second support rods (211) arranged in parallel and a second head (212) connecting one ends of the two second support rods (211), the other ends of the two second support rods (211) are provided with the second bent portions (22) to form welding ends, and the second bent portions (22) are bent along one side of the second coil body (21) along a width direction.

6. The 48-slot 8-pole flat-wire winding stator according to claim 1, characterized in that wherein the single coil comprises a third coil (3), the third coil (3) is disposed in the innermost layer of the slot opening as the neutral point lead-out wire, the third coil (3) comprises a third coil body (31) and a third bent portion (32), the third coil body (31) comprises a third support rod (311), both ends of the third support rod (311) are respectively provided with a third head portion (312) and the third bent portion (32), and the third bent portion (32) forms a welding end; and a bending direction of the third head portion (312) is opposite to a bending direction of the third bent portion (32).

7. The 48-slot 8-pole flat-wire winding stator according to claim 1, characterized in that wherein the concentric coil with a span of y comprises a fourth coil (4), the fourth coil (4) is commutated in the outermost layer of the slot bottom in the same layer, the fourth coil (4) comprises a fourth coil body (41) and a fourth bent portion (42), the fourth coil body (41) comprises two fourth support rods (411) arranged in parallel and a fourth head portion (412) connecting one ends of the two fourth support rods (411), the other ends of the two fourth support rods (411) are provided with the fourth bent portions (42) to form welding ends, and the fourth bent portions (42) are bent along one side of the fourth coil body (41) along a width direction.

8. The 48-slot 8-pole flat-wire winding stator according to claim 2, characterized in that wherein each of the phase windings comprises a group of winding branches, a first branch in the winding branches comprises a single coil A0, coils a1-A2, a3-A4, a5-A6, a7-A8, a9-A10, a11-A12, a13-A14, a15-A16, a17-A18, a19-A20, a21-A22, a23-A24, a25-A26, a27-A28, and a29-A30, and a single coil a31; a second branch in the winding branches comprises a single coil B0, coils b1-B2, b3-B4, b5-B6, b7-B8, b9-B10, b11-B12, b13-B14, b15-B16, b17-B18,

b19-B20, b21-B22, b23-B24, b25-B26, b27-B28, and b29-B30, and a single coil b31; a third branch in the winding branches comprises a single coil C0, coils c1-C2, c3-C4, c5-C6, c7-C8, c9-C10, c11-C12, c13-C14, c15-C16, c17-C18, c19-C20, c21-C22, c23-C24, c25-C26, c27-C28, and c29-C30, and a single coil c31;

the single coil A0, the single coil B0, and the single coil C0 are all located in a first layer of the core slot (51) along the slot opening toward the slot bottom, serving as winding starts; the single coil a31, the single coil b31, and the single coil c31 are all located in the first layer of the core slot (51) from the slot opening toward the slot bottom, serving as the neutral point lead-out wires;

a1-A2 and a17-A18 both have the span of y, with upper layer sides thereof located in a second layer of the core slot (51), and lower layer sides thereof located in the first layer of the core slot (51);

a3-A4 and a19-A20 both have the span of y, with upper layer sides thereof located in the second layer of the core slot (51), and lower layer sides thereof located in a third layer of the core slot (51);

a5-A6 and a21-A22 both have the span of y, with upper layer sides thereof located in a fourth layer of the core slot (51), and lower layer sides thereof located in a fifth layer of the core slot (51);

a7-A8 and a23-A24 both have the span of y, with upper layer sides and lower layer sides thereof both located in a sixth layer of the core slot (51);

a9-A10 and a25-A26 both have the span of y, with upper layer sides thereof located in the fifth layer of the core slot (51), and lower layer sides thereof located in the fourth layer of the core slot (51);

a11-A12 and a27-A28 both have the span of y, with upper layer sides thereof located in the third layer of the core slot (51), and lower layer sides thereof located in the second layer of the core slot (51);

a13-A14 and a29-A30 both have the span of y, with upper layer sides thereof located in the first layer of the core slot (51), and lower layer sides thereof located in the second layer of the core slot (51);

a15-A16 has the span of y-1, with an upper layer side and a lower layer side thereof both located in the first layer of the core slot (51);

b1-B2 and b17-B18 both have the span of y, with upper layer sides thereof located in the second layer of the core slot (51), and lower layer sides thereof located in the third layer of the core slot (51);

b3-B4 and b19-B20 both have the span of y, with upper layer sides thereof located in the fourth layer of the core slot (51), and lower layer sides thereof located in the third layer of the core slot (51);

b5-B6 and b21-B22 both have the span of y, with upper layer sides thereof located in the fourth layer of the core slot (51), and lower layer sides thereof located in the fifth layer of the core slot (51);

b7-B8 and b23-B24 both have the span of y, with upper layer sides and lower layer sides thereof both located in the sixth layer of the core slot (51);

b9-B10 and b25-B26 both have the span of y, with upper layer sides thereof located in the fifth layer of the core slot (51), and lower layer sides thereof located in the fourth layer of the core slot (51);

b11-B12 and b27-B28 both have the span of y, with upper layer sides thereof located in the third layer of the core slot (51), and lower layer sides thereof located in the fourth layer of the core slot (51);

b13-B14 and b29-B30 both have the span of y, with upper layer sides thereof located in the third layer of the core slot (51), and lower layer sides thereof located in the second layer of the core slot (51);

b15-B16 has the span of y-1, with an upper layer side and a lower layer side thereof both located in the first layer of the core slot (51);

c1-C2 and c17-C18 both have the span of y, with upper layer sides thereof located in the second layer of the core slot (51), and lower layer sides thereof located in the third layer of the core slot (51);

c3-C4 and c19-C20 both have the span of y, with upper layer sides thereof located in the fourth layer of the core slot (51), and lower layer sides thereof located in the fifth layer of the core slot (51);

c5-C6 and c21-C22 both have the span of y, with upper layer sides thereof located in the sixth layer of the core slot (51), and lower layer sides thereof located in the fifth layer of the core slot (51);

c7-C8 and c23-C24 both have the span of y, with upper layer sides and lower layer sides thereof both located in the sixth layer of the core slot (51);

c9-C10 and c25-C26 both have the span of y, with upper layer sides thereof located in the fifth layer of the core slot (51), and lower layer sides thereof located in the sixth layer of the core slot (51);

c11-C12 and c27-C28 both have the span of y, with upper layer sides thereof located in

the fifth layer of the core slot (51), and lower layer sides thereof located in the fourth layer of the core slot (51);

c13-C14 and c29-C30 both have the span of y, with upper layer sides thereof located in the third layer of the core slot (51), and lower layer sides thereof located in the second layer of the core slot (51);

c15-C16 has the span of y-1, with an upper layer side and a lower layer side thereof both located in the first layer of the core slot (51);

in the first branch of the windings, the coil A0 is connected to the coil a1-A2 through twisted-head welding, the coil a1-A2 is connected to the coil a3-A4 through twisted-head welding, the coil a3-A4 is connected to the coil a5-A6 through twisted-head welding, the coil a5-A6 is connected to the coil a7-A8 through twisted-head welding, and so on; a coil sequence goes from the first layer to the second layer, the second layer to the third layer, the third layer to the fourth layer, and the fourth layer to the fifth layer; after completing the same-layer winding in the sixth layer, the coil returns to the fifth layer, then goes to the fourth layer, further to the third layer, then to the second layer, and finally to the first layer; this cycle is repeated to complete the winding of the winding branches; the second branch and the third branch are similar to the first branch; and the winding is commutated through the coils in the same layer in the outermost layer of the slot bottom and the innermost layer of the slot opening, such that the three-phase windings are symmetrical.

9. The 48-slot 8-pole flat-wire winding stator according to claim 3, characterized in that wherein each of the phase windings comprises a group of winding branches, one branch in the winding branches comprises a single coil A0, coils a1-A2, a3-A4, a5-A6, a7-A8, a9-A10, a11-A12, a13-A14, a15-A16, a17-A18, a19-A20, a21-A22, a23-A24, a25-A26, a27-A28, a29-A30, a31-A32, a33-A34, a35-A36, a37-A38, a39-A40, a41-A42, a43-A44, a45-A46, and a47; another branch comprises a single coil B0, coils b1-B2, b3-B4, b5-B6, b7-B8, b9-B10, b11-B12, b13-B14, b15-B16, b17-B18, b19-B20, b21-B22, b23-B24, b25-B26, b27-B28, b29-B30, b31-B32, b33-B34, b35-B36, b37-B38, b39-B40, b41-B42, b43-B44, b45-B46, and b47;

the two branches have the same winding method, the single coil A0 and the single coil B0 are both located in the first layer of the core slot (51) from the slot opening toward the slot bottom, serving as winding starts; the single coil a47 and the single coil b47 are both located in the first layer of the core slot (51) from the slot opening toward the slot bottom, serving as neutral point lead-out wires;

a1-A2, a3-A4, a5-A6, a40-A41, b1-B2, b3-B4, b5-B6, and b40-B41 all have the span of y, with upper layer sides thereof located in a second layer of the core slot (51), and lower layer

sides thereof located in the first layer of the core slot (51);

a7-A8 and b7-B8 both have the span of y, with upper layer sides thereof located in the second layer of the core slot (51), and lower layer sides thereof located in a third layer of the core slot (51);

a9-A10, a11-A12, a13-A14, b9-B10, b11-B12, and b13-B14 all have the span of y, with upper layer sides thereof located in a fourth layer of the core slot (51), and lower layer sides thereof located in the third layer of the core slot (51);

a15-A16 and b15-B16 both have the span of y, with upper layer sides thereof located in the fourth layer of the core slot (51), and lower layer sides thereof located in a fifth layer of the core slot (51);

a17-A18, a19-A20, a21-A22, b17-B18, b19-B20, and b21-B22 all have the span of y, with upper layer sides thereof located in a sixth layer of the core slot (51), and lower layer sides thereof located in the fifth layer of the core slot (51);

a23-A24 and b23-B24 both have the span of y, with upper layer sides and lower layer sides thereof both located in the sixth layer of the core slot (51);

a25-A26, a27-A28, a29-A30, b25-B26, b27-B28, and b29-B30 all have the span of y, with upper layer sides thereof located in the fifth layer of the core slot (51), and lower layer sides thereof located in the sixth layer of the core slot (51);

a31-A32 and b31-B32 both have the span of y, with upper layer sides thereof located in the fifth layer of the core slot (51), and lower layer sides thereof located in the fourth layer of the core slot (51);

a33-A34, a35-A36, a37-A38, b33-B34, b35-B36, and b37-B38 all have the span of y, with upper layer sides thereof located in the third layer of the core slot (51), and lower layer sides thereof located in the fourth layer of the core slot (51);

a39-A40 and b39-B40 both have the span of y, with upper layer sides thereof located in the third layer of the core slot (51), and lower layer sides thereof located in the second layer of the core slot (51);

a41-A42, a43-A44, a45-A46, b41-B42, b43-B44, and b45-B46 all have the span of y, with upper layer sides thereof located in the first layer of the core slot (51), and lower layer sides thereof located in the second layer of the core slot (51);

in the first branch, the coil A0 is connected to the coil a1-A2 through twisted-head welding, the coil a1-A2 is connected to the coil a3-A4 through twisted-head welding, the coil a3-A4 is connected to the coil a5-A6 through twisted-head welding, the coil a5-A6 is connected to the coil a7-A8 through twisted-head welding, and so on; a coil connection sequence starts from the

first layer and the second layer, transitions to the third layer and the fourth layer, further transitions to the fifth layer and the sixth layer, finally realizes same-layer crossover in the sixth layer through the concentric coil, and then the coils are sequentially connected to the first layer; this cycle is repeated to complete the winding of the first branch, and the winding of the second branch follows the same rule, by parity of reasoning; and the winding is commutated through the outermost layer of the slot bottom, such that the three-phase windings are symmetrical.

10. A flat-wire motor, characterized in that comprising the 48-slot 8-pole flat-wire winding stator according to any one of claims 1 to 9.