

## PERMANENT-MAGNETIC SYNCHRONIZATION MOTOR

### BACKGROUND OF THE INVENTION

The present invention relates to a permanent-magnetic synchronization motor

There has been known a rotor having a structure where a plurality of permanent magnets and a plurality of cores, formed by a magnetic material and arranged in a non-contacted way each other, are arranged alternately and radially. Since the magnetic flux short-circuited between the cores is not converted to the torque, in order to gain high torque efficiently, it is necessary for the cores to be independent magnetically without mutual contact. In such a rotor, by installing an air gap between the cores, magnetic resistance between the cores is increased, each core is made magnetically independent, and a short-circuit between the cores, of a magnetic flux of the permanent magnet flowing the core, is prevented.

It is difficult to integrate a plurality of permanent magnets or a plurality of cores, and couple them to a rotation axis. There has been known the technology for integrating and fixing the whole rotor such as a permanent magnet, a core and a coupling component for a rotation axis, using a resin mold, mainly aiming at structural simplification and productivity enhancement; or the technology for installing a protrusion at the tip of the stator side of a core to hang the permanent magnet onto protrusion thereof (for example, refer to JP-A-11-341757 and JP-A-2003-533158).

### SUMMARY OF THE INVENTION

However, the resin mold has a problem of lower strength and shorter life time, as compared with a steel material or the like. In addition, in the technology for hanging the permanent magnet onto the protrusion of the core, the permanent magnet is fixed by the core, however, it cannot enhance strength and life-time of the whole rotor, in the case where the core is fixed at a rotation axis by a resin.

To solve the above problem, a permanent-magnetic synchronization motor, which is one aspect of the present invention, comprises a rotor and a stator. The rotor has a plurality of permanent magnets, a plurality of cores composed of a magnetic material, and a holding part which holds the plurality of permanent magnets and the plurality of cores, and is composed of a metal non-magnetic material. The holding part has a first flat plate part, which is a flat plate vertical to a rotation axis of the rotor, and a plurality of supporting parts installed on the first flat plate part and disposed in a circumferential direction of the rotor. A plurality of cores is each

arranged at a position between a plurality of supporting parts disposed in the circumferential direction. Each of the plurality of cores has a locking part which latches together to at least one of the plurality of supporting parts. A plurality of permanent magnets is each arranged at a position between the plurality of cores arranged in the circumferential direction.

5 (Technical Advantage)

According to the present invention, a permanent-magnetic synchronization motor having easy assembling, high strength and long life-time can be attained.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front view showing a motor structure.

10 Fig. 2 is a right side view showing a motor structure.

Fig. 3 is a magnified front view of a part of a motor.

Fig. 4 is a front cross-sectional view showing a motor structure.

Fig. 5 is a front magnified front cross-sectional view of a part of a motor.

Fig. 6 is a front view showing a structure of a back face cladding 3a.

15 Fig. 7 is a cross-sectional view showing a structure of a back face cladding 3a.

Fig. 8 is a front view showing a structure of a front face cladding 3b.

Fig. 9 is a cross-sectional view showing a structure of a front face cladding 3b.

Fig. 10 is a side view showing a tip part of a holding claw 5a before integration of  
a cage 3.

20 Fig. 11 is a side view showing a tip part of a holding claw 5b before integration of  
a cage 3.

Fig. 12 is a cross-sectional view showing a structure of a cage 3.

Fig. 13 is a cross-sectional view showing a tip part of a holding claw 5a after  
integration of a cage 3.

25 Fig. 14 is a cross-sectional view showing a tip part of a holding claw 5b after  
integration of a cage 3.

DESCRIPTION OF THE EMBODIMENT

Explanation will be given below on a structure of a motor relevant to the present  
Embodiment.

30 Fig. 1 is a front view showing a motor structure, Fig. 2 is a right side view  
showing a motor structure and Fig. 3 is a magnified front view of a part of a motor. A motor in  
the present Embodiment is an inner rotor-type permanent-magnetic synchronization motor, and

has a rotor 6 and a stator 12. That is, the stator 12 is arranged at the outer side of a diameter direction of the rotor 6, via an air gap. The stator 12 has a stator core 9 prepared by forming a laminated magnetic steel sheet. The stator core 9 has a cylindrical back yoke 7 forming the outer circumference of the stator 12, and a plurality of teeth 8 installed and arranged radially at the inside of a diameter direction of the back yoke 7. The stator 12 further has a coil 10 wound around the teeth 8, and an insulation material 11 covering the front side and the back face side of the coil 10. The coil 10 in this drawing is a concentrated winding wound around of each tooth 8, however, it may be a distributed winding wound over a plurality of teeth 8.

The 6 is connected to a rotation axis and rotates with the rotation axis. It should be noted that the rotor 6 may be connected to a body driven instead of the rotation axis. The rotor 6 has a plurality of permanent magnets 1, a plurality of cores 2, and a cage 3, which is a container for holding a plurality of permanent magnets 1 and a plurality of cores 2.

As shown in Fig. 3, the cage 3 has a back face cladding 3a forming a back face of the cage 3 and a front face cladding 3b forming a front face of the cage 3. In Fig. 3, a portion hidden inside the cage 3 among the permanent magnet 1 and the core 2 is shown by a broken line. The permanent magnet 1 and the core 2 are arranged radially from the center of the rotation axis, and arranged alternately in a circumferential direction of the rotor 6. In other words, a plurality of cores 2 are disposed in the circumferential direction, and each of a plurality of permanent magnets 1 is arranged between the two cores 2 adjacent each other. Therefore, number of the permanent magnet 1 is equal to number of the cores 2 (n pieces: n is an integer of 2 or more).

Explanation will be given below on an inner structure of the cage 3.

Fig. 4 is a front cross-sectional view showing a motor structure, and Fig. 5 is a front magnified front cross-sectional view of a part of a motor. The permanent magnet 1 is arranged so that a magnetization direction thereof, that is, a direction of the n-pole and the s-pole directs toward the circumferential direction of the rotor 6, and the adjacent cores 2 and the each other's same pole face to each other. By magnetizing the core 2 by magnetic flux of the permanent magnet 1, the n-pole and the s-pole align alternately in a circumferential direction, at the end part of the stator 12 side in the core 2. In this way, the rotor 6 of the permanent-magnetic synchronization motor can be configured.

As described above, since the core 2 is necessary to be magnetized by the permanent magnet 1, it is prepared by forming a magnetic material. To reduce iron loss such as eddy current loss or hysteresis loss, it is preferable that a laminated magnetic steel sheet or a dust core is used for the core 2.

Explanation will be given below on a holding method of the core 2 and the permanent magnet 1 by the cage 3.

As shown in Fig.5, the cage 3 has a plurality of holding claws 5a disposed in an equal interval along the outer circumferential of the rotor 6, and a plurality of holding claws 5b disposed in an equal interval along the inner circumferential of the rotor 6. A plurality of holding claws 5a and a plurality of holding claws 5b are each facing to a diameter direction of the rotor 6. Each of a plurality of the cores 2 is arranged between the two holding claws 5a adjacent to each other, and is arranged between the two holding claws 5b facing respectively to these two holding claws 5b. In other words, a plurality of cores 2 are each arranged at positions among a plurality of holding claws 5a in a circumferential direction of the rotor 6, and arranged at positions among a plurality of holding claws 5b in a circumferential direction of the rotor 6. Therefore, each of number of the holding claws 5a and number of the holding claws 5b is equal to number of the cores 2. It should be noted that the facing holding claws 5a and 5b may be a integrated body.

Among the core 2, length of a portion between the adjacent two holding claws 5a is set to be  $W_a$  and length of a portion between the adjacent two holding claws 5b is set to be  $W_b$ . In a state that the core 2 is not attached to the cage 3,  $W_a$  is equal to or less than the interval of the holding claws 5a, and  $W_b$  is equal to or less than the interval of the holding claws 5b. In producing a motor, each core 2 is pressed into the space between two holding claws 5a adjacent to each other and between two holding claws 5b adjacent to each other, by a press apparatus or the like. In this way, each of the cores 2 adheres closely to the adjacent two holding claws 5a, as well as adheres closely to the adjacent two holding claws 5b, and is fixed in a no play state. Accordingly, the holding claws 5a and 5b enable to prevent the core 2 from transfer in the circumferential direction.

The core 2 has two protrusions 2a which each protrudes from the end part of a stator 12 direction (centrifugal direction) to both directions of the circumferential direction, and two protrusions 2b which each protrudes from the end part of a pivot center direction (centripetal direction) to both directions of the circumferential direction. The protrusion 2a protrudes toward the stator 12 side of the holding claw 5a, and the protrusion 2b protrudes toward the pivot center side of the holding claw 5b. A pivot center side of the two protrusions 2a of the core 2 latches together each to the two holding claws 5a. Still more, the stator 12 side of the two protrusions 2b of the core 2 latches together each to the two holding claws 5b. Accordingly, the holding claws 5a and 5b enable to prevent the core 2 from transfer in the diameter direction.

Configuration of the above two cores 2 and the holding claws 5a and 5b enables

for the cage 3 to fix the core 2 firmly and easily. It should be noted that the core 2 may have only either of the two protrusions 2a, or may have only either of the two protrusions 2b. In addition, instead of the protrusions 2a and 2b, the core 2 may have a portion latching together to the holding claws 5a and 5b. For example, by installing a groove instead of the protrusion 2a, in the core 2, this groove may latch together to the holding claw 5a. Similarly, by installing a groove instead of the protrusion 2b, in the core 2, this groove may latch together to the holding claw 5b.

Each of a plurality of permanent magnets 1 is arranged between the adjacent two cores 2 in the circumferential direction, and arranged between the holding claws 5a and 5b opposing to the diameter direction. In other words, a plurality of permanent magnets 1 is each arranged at positions among a plurality of cores 2. Because motor torque or suction force to the stator 12 exerts on the core 2, the core 2 deforms slightly. Provided that the permanent magnet 1 and the core 2 are closely adhered, there is some possibility of crack of the permanent magnet 1 by deformation of the core 2. In the present Embodiment, among the permanent magnet 1, length of a portion between the adjacent two cores 2 is shorter than length between these two cores 2. In other words, there is a gap between the permanent magnet 1 and the core 2 adjacent to it. Such a gap enables to prevent crack of the permanent magnet 1. It should be noted that the holding claws 5a and 5b facing to each other may be an integrated body. For example, instead of the holding claws 5a and 5b, there may be installed a supporting part or a seat for limiting the transfer of the permanent magnet 1 in a diameter direction, on the flat plate part 4a.

Explanation will be given below on a structure of the each part of the cage 3.

Fig. 6 is a front view showing a structure of a back face cladding 3a. Fig. 7 is a cross-sectional view showing a structure of a back face cladding 3a. This cross-sectional drawing shows a cross-section, viewed from the A-A arrow, of the back face cladding 3a in Fig. 6. The back face cladding 3a has the flat plate part 4a forming a wall of the back face side of the cage 3, and the holding claw 5a arranged vertically at the front side of the flat plate part 4a and forming a wall of the stator 12 side. The flat plate part 4a has a through hole 20a for making pass through the tip of the holding claw 5b of the front cladding 3b, and the through hole 21 for making pass through a fixing member 13 installed at the rotation axis at the back face side.

Fig. 8 is a front view showing a structure of a front face cladding 3b. Fig. 9 is a cross-sectional view showing a structure of a front face cladding 3b. This cross-sectional drawing shows a cross-section, viewed from the C-C arrow, of the front face cladding 3b in Fig. 8. The front face cladding 3b has the flat plate part 4b forming a wall of the front side of the

cage 3, and the holding claw 5b arranged vertically at the back face side of the flat plate part 4b forming a wall of the pivot center side. The flat plate part 4b has a through hole 20b for making passed through the tip of the holding claw 5a of the back face cladding 3a.

Explanation will be given below on an assembling method for the cage 3 by  
5 integration of the back face cladding 3a and the front face cladding 3b.

Fig. 10 is a side view showing a tip part of a holding claw 5a before integration of a cage 3. This drawing shows a view from the B arrow of the holding claw 5a in Fig. 7. The holding claw 5a has a tip part 23a branched into two at the tip. Fig. 11 is a side view showing a tip part of a holding claw 5b before integration of a cage 3. This drawing shows a view from  
10 the D arrow of the holding claw 5a in Fig. 9. The holding claw 5b has a tip part 23b branched into two at the tip.

In this state, as for an assembly method for the cage 3, for example, the core 2 and the permanent magnet 1 are arranged on the flat plate part 4a of the back face cladding 3a. For example, by pressing into the core 2 between the adjacent two holding claws 5a, the permanent  
15 magnet 1 is arranged between the adjacent two cores 2.

Fig. 12 is a cross-sectional view showing a structure of a cage 3. This cross-sectional drawing shows a cross-section, viewed from the E-E arrow, of the cage 3 in Fig. 3. In an assembling method for the cage 3 after arranging the core 2 and the permanent magnet 1 on the flat plate part 4a, the flat plate part 4a of the back face cladding 3a and the flat plate part 4b  
20 of the front face cladding 3b are faced to each other to combine the back face cladding 3a and the front face cladding 3b. In this time, the tip part 23b of the holding claw 5b of the front face cladding 3b is inserted and penetrated through the through hole 20a of the back face cladding 3a, as well as the tip part 23a of the holding claw 5a of the back face cladding 3a is inserted and  
penetrated through the through hole 20b of the front face cladding 3b. Still more, the core 2 is  
25 pressed into the space between the adjacent two holding claws 5b. In this state, the stator 12 side of the permanent magnet 1 is covered with the holding claw 5a, and the pivot center side of the permanent magnet 1 is covered with the holding claw 5b. By penetration of the tip part 23b through the through hole 20a and penetration of the tip part 23a through the through hole 20b, positional relation between the back face cladding 3a and the front face cladding 3b can be  
30 determined easily and correctly.

Fig. 13 is a cross-sectional view showing a tip part of a holding claw 5a after integration of a cage 3, and Fig. 14 is a cross-sectional view showing a tip part of a holding claw 5b after integration of a cage 3. After combining the back face cladding 3a and the front face cladding 3b, in an assembling method for the cage 3, each of the two branched part of the tip part

23a is extended so as to be placed along the front face of the flat plate part 4b, by plastic deformation of the tip part 23a of the holding claw 5a protruding to the front side of the flat plate part 4b. Similarly, each of the two branched part of the tip part 23b is extended so as to be placed along the back face of the flat plate part 4a, by plastic deformation of the tip part 23b of the holding claw 5b protruding to the back face side of the flat plate part 4a. For example, by widening the tip part 23a and 23b, using a press machine or the like, the tip part 23a and 23b can be subjected to plastic deformation.

In this time, as for the predetermined direction parallel to the flat plate part 4b, dimension of a part at the front side of the flat plate part 4b among the tip part 23a becomes larger than dimension of the opening of the through hole 20b. Similarly, in the predetermined direction parallel to the flat plate part 4a, dimension of a part at the back face side of the flat plate part 4a in the tip part 23b becomes larger than dimension of the opening of the through hole 20a. In this way, the tip part 23a latches together to the front side of the through hole 20b, and the tip part 23b latches together to the back face side of the through hole 20a. This configuration enables easy connection of the back face cladding 3a and the front face cladding 3b.

Connection of the back face cladding 3a and the front face cladding 3b provides sandwiching and holding of a plurality of permanent magnets 1 and a plurality of cores 2, between the flat plate parts 4a and 4b. It should be noted that the flat plate parts 4a and 4b may support the permanent magnet 1 and the core 2 by a shape other than a flat plate. For example, either of the flat plate parts 4a and 4b may be a circular ring vertical to a rotation axis.

After the cage 3 is assembled, by insertion and penetration of the fixing member 13 from the front side into the through hole 21, and by fixing the fixing member 13 to the rotation axis at the back face side of the through hole 21, the cage 3 is fixed to the rotation axis. The fixing member 13 is a bolt or a pin or the like. In this way, the cage 3 can be connected firmly to the rotation axis.

The cage 3 is prepared by forming a metal non-magnetic material. The metal non-magnetic material is preferably, for example, steel such as stainless steel. It should be noted that the cage 3 may be composed of other metal non-magnetic material such as aluminum or an alloy thereof. By adoption of the non-magnetic material as a material of the cage 3, magnetic flux of the permanent magnet 1 prevents from the cores 2 being short circuited between via the cage 3. In addition, by adoption of steel as a material of the cage 3, strength and life-time can be enhanced, as compared with a conventional resin mold. For example, by forming a metal plate by punching using a metal mold to prepare the holding claws 5a and 5b by bending,

the back face cladding 3a and the front face cladding 3b can be prepared, respectively. In this way, the back face cladding 3a and the front face cladding 3b can be prepared easily.

In addition, an assembly method in the case of using a conventional resin mold required a step for temporary positioning of the permanent magnet 1 or the core 2 using a positioning apparatus or a tool, a step for performing resin molding while maintaining state thereof, and finally a step for removing the positioning apparatus or the tool. In the present Embodiment, positioning of the permanent magnet 1 or the core 2 is possible by the holding claws 5a and 5b of the cage 3, and thus it is enough only to insert the core 2 or the permanent magnet 1 between the holding claws 5a in assembling, and connect the back face cladding 3a and the front face cladding 3b. That is, the present Embodiment enables assembling of the rotor 6 easier as compared with a conventional method.

As has been explained above, by holding and integrating a plurality of permanent magnets 1 and a plurality of cores 2 by a firm cage 3, and fixing the cage 3 at the rotation axis, easy production of the rotor 6 having high strength and long life-time becomes possible. In addition, by enhancing strength of the rotor 6, torque of the motor can be enhanced. In this way, the motor of the present Embodiment can be utilized in a winding machine etc. of an elevator.

Explanation will be given below on other Embodiments.

In the above Embodiments, the holding claw 5a is installed at the back face cladding 3a, and the holding claw 5b is installed at the front face cladding 3b, however, both of the holding claws 5a and 5b may be installed at only either of the back face cladding 3a and the front face cladding 3b.

In the above Embodiment, the cage 3 was explained as having a two divided structure of the back face cladding 3a and the front face cladding 3b, however, it may be subdivided by dividing the cage 3 in a circumferential direction or the like.

The motor of the above Embodiment was explained as the inner rotor-type permanent-magnetic synchronization motor, however, it may be an outer rotor-type permanent-magnetic synchronization motor.

Technology explained in the above Embodiments may be represented as follows.

(Representation 1)

A permanent-magnetic synchronization motor comprising a rotor and a stator, wherein

the rotor has a plurality of permanent magnets, a plurality of cores composed of a magnetic material, and a holding part which holds the plurality of permanent magnets and the

plurality of cores, and is composed of a metal non-magnetic material;

the holding part has a first flat plate part, which is a flat plate vertical to a rotation axis of the rotor, and a plurality of supporting parts installed on the first flat plate part and disposed in a circumferential direction of the rotor;

5 the plurality of cores is each arranged at a position between the plurality of supporting parts disposed in the circumferential direction;  
each of the plurality of cores has a locking part which latches together to at least one of the plurality of supporting parts; and

the plurality of permanent magnets is each arranged at a position between the  
10 plurality of cores arranged in the circumferential direction.

(Representation 2)

The permanent-magnetic synchronization motor according to the Representation 1, wherein each of the plurality of supporting parts has a first supporting part installed at the stator side relative to an adjacent permanent magnet and a second supporting part installed at the  
15 opposite side of the stator relative to the adjacent permanent magnet.

(Representation 3)

The permanent-magnetic synchronization motor according to Representation 2, wherein each of the locking part of the plurality of cores has a first locking part which latches together to an adjacent first supporting part, and a second locking part which latches together to  
20 the adjacent first supporting part.

(Representation 4)

----- The permanent-magnetic synchronization motor according to Representation 3, wherein

the first locking part protrudes from the adjacent first supporting part, at the stator  
25 side, in the circumferential direction and

the second locking part protrudes from the adjacent second supporting part, at the opposite side of the stator, in the circumferential direction.

(Representation 5)

The permanent-magnetic synchronization motor according to any one of  
30 Representations 1 to 4, wherein each of the plurality of cores adheres closely to the adjacent two supporting parts.

(Representation 6)

The permanent-magnetic synchronization motor according to any one of Representations 1 to 5, wherein each of the plurality of permanent magnets forms a space

between the adjacent cores.

(Representation 7)

The permanent-magnetic synchronization motor according to any one of Representations 1 to 6, wherein the metal is steel.

5 (Representation 8)

The permanent-magnetic synchronization motor according to Representation 2, wherein the holding part further has the second flat plate part, which is a flat plate facing to the first flat part, via the plurality of permanent magnets and the plurality of cores, and is connected to at least one of the first supporting part and the second supporting part in the plurality of

10 supporting parts.

(Representation 9)

The permanent-magnetic synchronization motor according to Representation 8, wherein

the second flat plate part has a through hole, and

15 a tip part of at least one of the first supporting part and the second supporting part in the plurality of supporting parts penetrates through the through hole.

(Representation 10)

The permanent-magnetic synchronization motor according to Representation 9, wherein as for predetermined direction vertical to the rotation axis, dimension of a part protruded

20 from the second flat plate part among the tip parts is larger than dimension of the opening of the through hole.

Explanation will be given below on the terms in these representations. The holding part, for example, corresponds to the cage 3. The supporting part, for example, corresponds to the holding claws 5a and 5b. The locking part, for example, corresponds to the

25 protrusions 2a and 2b. The first flat plate part, for example, corresponds to the flat plate part 4a. The second flat plate part, for example, corresponds to the flat plate part 4b. The first supporting part, for example, corresponds to the holding claw 5a. The second supporting part, for example, corresponds to the holding claw 5b. The first protrusion part, for example, corresponds to the protrusion 2a. The second protrusion part, for example, corresponds to the

30 protrusion 2b.

**CLAIMS:**

1. A permanent-magnetic synchronization motor comprising a rotor (6) and a stator (12), wherein

said rotor (6) has a plurality of permanent magnets (1), a plurality of cores (2) composed of a magnetic material, and a holding part which holds said plurality of permanent magnets (1) and said plurality of cores (2), and is composed of a metal non-magnetic material;

said holding part has a first flat plate part (4a), which is a flat plate vertical to a rotation axis of said rotor (6), and a plurality of supporting parts installed on said first flat plate part (4a) and disposed in a circumferential direction of said rotor (6);

said plurality of cores (2) is each arranged at a position between said plurality of supporting parts disposed in the circumferential direction;

each of said plurality of cores (2) has a locking part which latches together to at least one of said plurality of supporting parts; and

said plurality of permanent magnets (1) is each arranged at a position between said plurality of cores (2) arranged in the circumferential direction;

wherein each of said plurality of supporting parts has a first supporting part installed at said stator (12) side relative to an adjacent permanent magnet (1), and a second supporting part installed at the opposite side of said stator (12) relative to said adjacent permanent magnet (1); and

wherein each of the locking part of said plurality of cores (2) has a first locking part which latches together to an adjacent first supporting part, and a second locking part which latches together to adjacent first supporting part.

2. The permanent-magnetic synchronization motor according to claim 1, wherein

said first locking part protrudes in said circumferential direction at the stator (12) side than the adjacent first supporting part, and

said second locking part protrudes in said circumferential direction at the opposite side of said stator (12) than the adjacent second supporting part.

3. The permanent-magnetic synchronization motor according to claim 1 or 2, wherein each of said plurality of cores (2) adheres closely to the adjacent two

supporting parts.

4. The permanent-magnetic synchronization motor according to any one of claims 1 to 3, wherein each of said plurality of permanent magnets (1) forms a space between the adjacent cores (2).

5. The permanent-magnetic synchronization motor according to any one of claims 1 to 4, wherein said metal is steel.

6. The permanent-magnetic synchronization motor according to claim 1, wherein said holding part further has the second flat plate part (4b), which is a flat plate facing to the first flat part (4a) via said plurality of permanent magnets (1) and said plurality of cores (2), and is connected to at least one of the first supporting part and the second supporting part in said plurality of supporting parts.

7. The permanent-magnetic synchronization motor according to claim 6, wherein

said second flat plate part (4b) has a through hole, and  
a tip part of at least one of the first supporting part and the second supporting part in said plurality of supporting parts penetrates through said through hole.

8. The permanent-magnetic synchronization motor according to claim 7, wherein, as for predetermined direction vertical to said rotation axis, dimension of a part protruded from said second flat plate part (4b) among said tip parts is larger than dimension of the opening of said through hole.