CLAIMS

[Claim 1] A rotor core comprising a soft magnetic material portion formed using a soft magnetic material, and having at least one magnet hole per one pole, wherein:

the magnet hole has, relative to a permanent magnet installed through the magnet hole, a space serving as a front-side flux barrier and a space serving as a rear-side flux barrier on both sides in a left-right direction perpendicular to a magnetization direction of the permanent magnet and a direction parallel to a rotation axis line serving as a center of rotation;

the space serving as at least one flux barrier, of the space serving as the front-side flux barrier and the space serving as the rear-side flux barrier, has an open end portion opened in an outer peripheral surface of the rotor core;

in a cross section perpendicular to the rotation axis line, the front-side flux barrier is on a front side in a rotation direction of the rotor core than the rear-side flux barrier;

in the cross section, a position of an open-end front-side corner portion of at least one of the open end portions provided in a same pole of a rotor is on a rear side in a rotation direction of the rotor core further than a reference position relative to the magnet hole having the open end portion;

in the cross section, the open-end front-side

corner portion is a corner portion on a front side in the rotation direction of the rotor core, of two corner portions in a circumferential direction of the rotor core, of at least one of the open end portions provided in the same pole of the rotor;

in the cross section, the reference position relative to the magnet hole having the open end portion is a position at an intersection point of a straight line passing through a permanent-magnet reference end portion which is one of end portions of the permanent magnet at a position closest to the open end portion in the permanent magnet installed through the magnet hole, and the rotation axis line, and, the outer peripheral surface of the rotor core;

in the cross section, the permanent-magnet reference end portion of the permanent magnet at the position closest to the open end portion is, of end portions of the permanent magnet, an end at a position at a farthest distance in the circumferential direction from a straight line passing through a central position in the circumferential direction of a region of one pole including the permanent magnet, and the rotation axis line; and

the distance in the circumferential direction from a straight line passing through the central position in the circumferential direction of the region in one pole including the permanent magnet at the position closest to the open end portion, and the

rotation axis line is a distance defined on a side, of the front side and the rear side in the rotation direction of the rotor core, in which the open end portion is present.

[Claim 2] The rotor core according to claim 1, wherein in the cross section, positions of the open-end front-side corner portions of all the open end portions provided in the same pole of the rotor are each on the rear side in the rotation direction of the rotor core further than the reference position relative to the magnet hole having the open end portion.

[Claim 3] The rotor core according to claim 1 or 2, wherein:

the rotor core has a plurality of magnet holes per one pole;

the plurality of magnet holes have a front-side magnet hole positioned on the front side in the rotation direction, and a rear-side magnet hole positioned on the rear side in the rotation direction;

the space serving as the front-side flux barrier included in the front-side magnet hole is an outer-peripheral-side flux barrier on the front side in the rotation direction and on an outer peripheral side of the rotor core further than the space serving as the rear-side flux barrier included in the front-side magnet hole;

the space serving as the rear-side flux barrier

included in the rear-side magnet hole is an outer-peripheral-side flux barrier on the rear side in the rotation direction and on the outer peripheral side of the rotor core further than the space serving as the front-side flux barrier included in the rear-side magnet hole;

the space serving as at least one flux barrier, of the space serving as the front-side flux barrier included in the front-side magnet hole and the space serving as the rear-side flux barrier included in the rear-side magnet hole, has the open end portion;

in the cross section, the open-end front-side corner portion has at least one of a front-side open-end front-side corner portion and a rear-side open-end front-side corner portion;

in the cross section, the front-side open-end front-side corner portion is, of two corner portions in the circumferential direction of the rotor core of a front-side open end portion, a corner portion on the front side in the rotation direction;

in the cross section, the front-side open end portion is the open end portion of the space serving as the front-side flux barrier included in the front-side magnet hole;

in the cross section, the rear-side open-end front side corner portion is, of two corner portions in the circumferential direction of the rotor core of a rear -side open end portion, a corner portion on the front side in the rotation direction;

in the cross section, the rear-side open-end portion is the open end portion of the space serving as the rear-side flux barrier included in the rear-side magnet hole;

in the cross section, the permanent-magnet reference end portion has at least one of a front-side permanent magnet end portion and a rear-side permanent magnet end portion;

in the cross section, the front-side permanent magnet end portion is, of the end portions of the permanent magnet installed through the front-side magnet hole, the end portion at a position on a foremost side in the rotation direction;

in the cross section, the rear-side permanent magnet end portion is, of the end portions of the permanent magnet installed through the rear-side magnet hole, the end portion at a position on a rearmost side in the rotation direction;

in the cross section, the reference position has at least one of a front-side reference position and a rear-side reference position;

in the cross section, the front-side reference position is the position at an intersection point of a straight line passing through the front-side permanent magnet end portion and the rotation axis line, and the outer peripheral surface of the rotor core; and

in the core cross section, the rear-side reference position is the position at an intersection

point of a straight line passing through the rear-side permanent magnet end portion and the rotation axis line, and the outer peripheral surface of the rotor core.

[Claim 4] The rotor core according to claim 3, wherein:

the open-end front-side corner portion has the front-side open-end front-side corner portion and the rear-side open-end front-side corner portion;

the permanent-magnet reference end portion has the front-side permanent magnet end portion and the rear-side permanent magnet end portion;

the reference position has the front-side reference position and the rear-side reference position; and

the space serving as the front-side flux barrier included in the front-side magnet hole and the space serving as the rear-side flux barrier included in the rear-side magnet hole each have the open end portion.

[Claim 5] The rotor core according to any one of claims 1 to 4, wherein:

in the cross section, an angle formed by a straight line passing through the open-end front-side corner portion positioned on the front side in the rotation direction further than a center in the circumferential direction in the same pole, of the open-end front-side corner portions, and the rotation axis line, and, a straight line passing through the reference position relative to the magnet hole having

the open end portion with the open-end front-side corner portion set as one of corner portions, and the rotation axis line is not less than θa/24 nor more than 15θa/24;

θa is a movement angle (rad) which is an angle around the rotation axis line from the reference position;

θa is calculated by $2\pi/N_{slot}$; and

N_{slot} is the number (piece) of slots in a stator core installed in a position opposite apart from the outer peripheral surface of the rotor core.

[Claim 6] The rotor core according to any one of claims 1 to 5, wherein:

in the cross section, an angle formed by a straight line passing through the open-end front-side corner portion positioned on the rear side in the rotation direction further than the center in the circumferential direction in the same pole, of the open-end front-side corner portions, and the rotation axis line, and, a straight line passing through the reference position relative to the magnet hole having the open end portion with the open-end front-side corner portion set as one of corner portions, and the rotation axis line is not less than θa/24 nor more than θa/8;

θa is a movement angle (rad) which is the angle around the rotation axis line from the reference position;

θa is calculated by $2\pi/N_{slot}$; and

N_{slot} is the number (piece) of slots in the stator core installed in the position opposite apart from the outer peripheral surface of the rotor core.

[Claim 7] The rotor core according to any one of claims 1 to 6, wherein a length in the circumferential direction of the open end portion is not less than 0.1 times nor more than 1.0 times a length in the magnetization direction of the permanent magnet installed through the magnet hole having the open end portion.

[Claim 8] The rotor core according to any one of claims 1 to 7, wherein:

the soft magnetic material portion further has a recess portion having an open end portion opened in the outer peripheral surface of the rotor core as a recess portion different from the space serving as the flux barrier; and

the recess portion is in a position opposite apart from teeth different from teeth having a lowest magnetic flux density of teeth of the stator core installed in the position opposite apart from the outer peripheral surface of the rotor core.

[Claim 9] The rotor core according to claim 8, wherein:

in the cross section, an angle formed by a straight line passing through a recess rear-side corner portion which is, of two corner portions in the open end portion of the recess portion, a corner portion on the rear side in the rotation direction,

and the rotation axis line, and, a straight line passing through the open-end front-side corner portion positioned on the rear side in the rotation direction further than the recess portion in the same pole as a pole in which the recess portion is installed, and the rotation axis is θa;

an angle formed by a straight line passing through a recess front-side corner portion which is, of the two corner portions in the open end portion of the recess portion, the corner portion on the front side in the rotation direction, and the rotation axis line, and, a straight line passing through the recess rear-side corner portion and the rotation axis line is not less than θa/8 nor more than 25θa/24θa;

θa is the movement angle (rad) which is the angle around the rotation axis line from a rear-side reference position which is the position at an intersection point of a straight line passing through a rear-side permanent magnet end portion and the rotation axis line, and the outer peripheral surface of the rotor core, in the cross section;

the rear-side permanent magnet end portion is, of the end portions of the permanent magnet installed in the same pole, the end portion positioned on a rearmost side in the circumferential direction;

θa is calculated by $2\pi/N_{slot}$; and

N_{slot} is the number (piece) of slots in the stator core installed in the position opposite apart from the outer peripheral surface of the rotor core.

[Claim 10] The rotor core according to claim 8 or 9, wherein a maximum value of a depth of the recess portion is within a range of not less than 0.01 times nor more than 0.1 times a diameter of the rotor core.

[Claim 11] The rotor core according to any one of claims 1 to 10, wherein

the rotor core has a plurality of magnet holes per one pole;

the plurality of magnet holes have a front-side magnet hole positioned on the front side in the rotation direction, and a rear-side magnet hole positioned on the rear side in the rotation direction;

the space serving as the front-side flux barrier included in the front-side magnet hole is on the front side in the rotation direction further than the space serving as the rear-side flux barrier included in the front-side magnet hole;

the space serving as the front-side flux barrier included in the rear-side magnet hole is on the front side in the rotation direction further than the space serving as the rear-side flux barrier included in the rear-side magnet hole;

the soft magnetic material portion has an inter-magnet bridge portion disposed in a region between the space serving as the rear-side flux barrier included in the front-side magnet hole and the space serving as the front-side flux barrier included in the rear-side magnet hole;

the front-side magnet hole has a first end portion serving as the open end portion on the front side in the rotation direction relative to the permanent magnet installed through the front-side magnet hole;

the front-side magnet hole has a second end portion on the rear side in the rotation direction relative to the permanent magnet installed through the front-side magnet hole;

the rear-side magnet hole has a first end portion serving as the open end portion on the rear side in the rotation direction relative to the permanent magnet installed through the rear-side magnet hole;

the rear-side magnet hole has a second end portion on the front side in the rotation direction relative to the permanent magnet installed through the rear-side magnet hole; and

the second end portion of each of the front-side magnet hole and the rear-side magnet hole coincides with an end portion of the space serving as the flux barrier, and is closed.

[Claim 12] The rotor core according to claim 11, wherein:

in the cross section, a length, of a portion overlapping with the soft magnetic material, of a bridge-width specified line is 0.02 times or less the diameter of the rotor core; and

the bridge-width specified line is a straight line connecting the second end portions of the front-

side magnet hole and the rear-side magnet hole to make a length of the overlap with the soft magnetic material shortest.

[Claim 13]

The rotor core according to claim 11 or 12, wherein:

in the cross section, each of the front-side magnet hole and the rear-side magnet hole further has a third end portion positioned on the outer peripheral side in the magnetization direction of the permanent magnet installed through each of the front-side magnet hole and the rear-side magnet hole, and a fourth end portion positioned on an inner peripheral side in the magnetization direction of the permanent magnet further than the third end portion;

in the cross section, a length, of a portion overlapping with the soft magnetic material, of a bridge-width specified line exceeds w_{min};

the bridge-width specified line is a straight line connecting the second end portions of the front-side magnet hole and the rear-side magnet hole to make a length of the overlap with the soft magnetic material shortest;

w_{min} is calculated by $\rho \times S \times r_g \times \omega \div Ys$;

ρ is a density (kg/m^3) of the soft magnetic material;

Ys is a yield stress (Pa) at room temperature of the soft magnetic material;

S is an area (m^2) of an external force influence

portion;

the external force influence portion is a region of the soft magnetic material surrounded by the third end portion of the front-side magnet hole positioned at one end of the bridge-width specified line, the third end portion of the rear-side magnet hole positioned at the other end of the bridge-width specified line, an outer peripheral surface of the soft magnetic material portion, and the bridge-width specified line, in the cross section;

r_g is a distance (m) in a radial direction between a position of a center of gravity of the external force influence portion and the center of the rotation in the cross section; and

ω is an angular speed (rad/sec) of the rotor at a time of rotation at a maximum rotation speed.

[Claim 14] A rotor core comprising a soft magnetic material portion formed using a soft magnetic material, and having at least one magnet hole per one pole, wherein:

the soft magnetic material portion has a recess portion in an outer peripheral surface;

the magnet hole has a first end portion and a second end portion in a left-right direction perpendicular to a magnetization direction of a permanent magnet installed through the magnet hole and a direction parallel to a rotation axis line serving as a center of rotation;

at least one end portion of the first end portion

and the second recess portion is an opened open end portion;

the recess portion is in a position different from the open end portion; and

the recess portion is in a position opposite apart from teeth different from teeth having a lowest magnetic flux density of teeth of the stator core installed in a position opposite apart from the outer peripheral surface of the rotor core.

[Claim 15] A rotor comprising:

the rotor core according to any one of claims 1 to 14; and

a plurality of permanent magnets installed in the rotor core.

[Claim 16] The rotor according to claim 15, wherein a residual magnetic flux density at room temperature of the permanent magnet is 0.8 T or less.

[Claim 17] The rotor according to claim 15 or 16, wherein the permanent magnet contains no rare earth.

[Claim 18]

A rotary electric machine comprising:

the rotor according to any one of claims 15 to 17; and

a stator.