of the second end portion 312 of the hole 310 functions as a flux barrier, the region of the soft magnetic body serves as a bridge portion, giving rise to a magnetic flux 701 that recirculates in the rotor core 111 without proceeding to the stator core 121. For this reason, the torque of the IPMSM 100 cannot be increased by that amount. However, as mentioned above, in order for the region of the rotor core 111 on the outer peripheral side of the hole 310 to not have a shape that would be floating in midair, in the present embodiment, the second end portion 312 of the hole 310 is not open.

[0044] Here, as shown in FIG. 6, let it be assumed that in the second end portion 312 of the hole 310 also, a second outer space 310c that is the same as the first outer space 310b of the first end portion 311 of the hole 310 is formed, and that a circumferential direction length L12 of the second end portion 312 of the hole 310 is longer than the width direction length L1 of the inner space 310a. It will be noted that the circumferential direction length L12 of the end portion 312 on the trailing side of the rotor core 111 is a length in the circumferential direction heading in a direction toward the leading side from an endpoint 411 of the second end portion 312 of the hole 310 on the trailing side to an endpoint 412 of the second end portion 312 of the hole 310 on the leading side. The circumferential direction length L12 of the end portion 312 on the trailing side of the rotor core 111 may approximate the width direction length of the end portion 312 (the linear distance between the endpoint 411 and the endpoint 412) on the trailing side of the rotor core 111.

[0045] In a case where this is assumed, it is preferred that the second end portion 312 of the hole 310 be off-center on the leading side in the circumferential direction relative to a center position 413 of the inner space 310a at the position where the inner space 310a communicates with the second outer space 310c. That is, it would be preferred that a circumferential direction center position 414 of the second end portion 312 of the hole 310 be on the leading side in the circumferential direction relative to the circumferential direction center position 413 of the inner space 310a at the position where the inner space 310a communicates with the second outer space 310c. This corresponds, in FIG. 6, to the circumferential direction center position 414 of the second end portion 312 of the hole 310 being positioned on the leading side in the circumferential direction relative to an extrapolated center position 416 of the inner space 310a of the hole 310. The extrapolated center position 416 of the inner space 310a of the hole 310 is the position of an intersection between the second end portion 312 of the hole 310 and a straight line extending along the radial direction of the rotor core 111 from the center position 413 of the inner space 310a at the position (boundary) where the inner space 310a communicates with the second outer space 310c (the dashed line extending from the center position 413 in FIG. 6).

a sectional view of the rotor 1200 as cut perpendicular to a centerline O of the rotor 1200 and corresponds to FIG. 2. The shape of the rotor cross-section has the shape shown in FIG. 12 in any position in the z-axis direction of the rotor 1200. Furthermore, as in examples 1 and 2, in comparative example 2, a case where the number of poles that the IPMSM has is four is described as an example. Furthermore, in FIG. 12 also, as in FIG. 2, only a portion configuring one pole of the rotor 1200 is assigned reference signs, and reference signs for portions configuring the other three poles of the rotor 1200 are omitted, because otherwise the notation would become complicated. As shown in FIG. 12, in the rotor 1200 of comparative example 2, in the rotor core cross-section, both a first end portion 1211 of the hole in which the permanent magnet 112 is installed and a second end portion 1212 of the hole in which the permanent magnet 112 is installed are open. However, the circumferential direction length of the first end portion 1211 of the hole in which the permanent magnet 112 is installed and the circumferential direction length of the second end portion 1212 of the hole in which the permanent magnet 112 is installed are the same (substantially the same as a length L1 corresponding to the length of the permanent magnet 112 in the direction of magnetization Dm).

[0070] When the rotor 1100 of comparative example 1 shown in FIG. 11 was used, the torque T of the IPMSM was 0.800 Nm. By contrast, when the rotor 110 of example 1 shown in FIG. 2 was used, the torque T of the IPMSM was 1.199 Nm. In this way, in example 1, the torque T of the IPMSM increased 49.9% over that of comparative example 1. Consequently, it can be understood that by forming the first outer space 310b on the leading side of the hole 310 in the left and right direction Ds as shown in FIG. 3, the torque T of the IPMSM can be increased.

[0071] Furthermore, when the rotor 1200 of comparative example 2 shown in FIG. 12 was used, the torque T of the IPMSM was 0.956 Nm. By contrast, when the rotor 810 of example 2 shown in FIG. 8 was used, the torque T of the IPMSM was 1.251 Nm. In this way, in example 2, the torque T of the IPMSM increased 30.8% over that of comparative example 2. Consequently, it can be understood that by forming the first outer space 910b on the leading side of the hole 910 in the left and right direction Ds as shown in FIG. 9, the torque T of the IPMSM can be increased.

[0072] Furthermore, comparing example 1 and comparative example 1, the amount of increase in the torque resulting from forming the first outer space 310b on the leading side of the hole 310 in the left and right direction Ds is 0.399 (= 1.199 − 0.800) Nm. Furthermore, comparing example 1 and example 2, the amount of increase in the torque resulting from communicating the second end portion 912 of the hole 910 with the outer peripheral surface

CLAIMS

Claim 1. A rotor core comprising plural holes in which permanent magnets are installed, wherein:

in a cross-section of the rotor core perpendicular to a rotational axis serving as a center of rotation, at least one of the plural holes includes a first end portion positioned on a leading side in a rotational direction in a left and right direction, which is a direction on both left and right sides relative to a direction of magnetization of the permanent magnet, and a second end portion positioned on a trailing side in the rotational direction in the left and right direction;

the first end portion is open to an outer peripheral surface of the rotor core, and a circumferential direction length of the opening is longer than a circumferential direction length of the second end portion;

in the cross-section, the hole in which the first end portion is open has an inner space whose width direction length is equal to a length corresponding to a length of the permanent magnet in the direction of magnetization and a first outer space that communicates with the inner space, has the first end portion as one end portion of the hole in the left and right direction, and is wider than the inner space; and

the first end portion is disposed off-center on the trailing side in the rotational direction relative to a circumferential direction center position of the inner space at a position where the inner space communicates with the first outer space.

Claim 2. The rotor core of claim 1, wherein:

in the cross-section, a circumferential direction length in a direction heading toward the trailing side in the rotational direction from a trailing side endpoint extrapolated position of the inner space to an endpoint on the trailing side in the rotational direction among endpoints of the first end portion is equal to or greater than the width direction length of the inner space, and

the trailing side endpoint extrapolated position of the inner space is a position of an intersection between the first end portion and a straight line extending along a radial direction of the rotor core from an endpoint of the inner space on the trailing side at the position where the inner space communicates with the first outer space in the cross-section.

Claim 3. The rotor core of claim 1 or claim 2, wherein, in a hole wall surface configuring the hole, a trailing side wall surface configuring a trailing side of the first outer space in the rotational direction is inclined relative to a direction orthogonal to the rotational axis.

Claim 4. The rotor core of claim 3, wherein at least part of the trailing side wall surface is concavely curved.

Claim 5. The rotor core of any one of claim 1 to claim 4, wherein, in the cross-section, the circumferential direction length of the opening is longer than a length, in the direction of magnetization of the permanent magnet, of a region of the hole occupied by the permanent magnet.

Claim 6. The rotor core of any one of claim 1 to claim 5, wherein, in the cross-section, first end portions of all the holes are open.

Claim 7. The rotor core of any one of claim 1 to claim 6, wherein, in the cross-section, a second end portion of at least one of the holes is not open.

Claim 8. The rotor core of any one of claim 1 to claim 7, wherein, in the cross-section, second end portions of all the holes are not open.

Claim 9. A rotor comprising:

the rotor core of any one of claim 1 to claim 8; and

the permanent magnets.

Claim 10. A rotating electrical machine comprising:

the rotor of claim 9; and

a stator.