

Description

The invention relates to an electric motor comprising a rotor which includes a permanent magnet and a stator which includes an iron body which is coaxial with the rotor and which in an axial direction of the rotor is bounded by a substantially plane surface which extends substantially perpendicular to the rotor shaft, which iron body forms stator teeth which comprise radial limbs which carry tooth surfaces which cooperate with the rotor, stator coils being arranged around at least some of said limbs of the iron body and having outer and inner coil ends having end surfaces, whereby a part of each coil extends from the said plane surface in the said axial direction.

Such motors are described in inter alia DE—OS 28 35 210, DE—OS 31 22 049, and NL—OS 79 08 925. In these motors the permanent magnet in the rotor is a radially magnetized cylindrical magnet which surrounds the stator and which cooperates with the radial end faces of the stator teeth in the known motor (the said tooth surfaces). If smaller axial dimensions of these motors are required in order to obtain flatter motors, the surface area of the tooth surfaces which face the rotor magnet will become too small to intercept the magnetic flux that can be produced by the rotor magnet. In the motor described in DE—OS 31 22 049 the iron stator body is therefore provided with flux conductors in order to increase the axial dimension of said tooth surfaces. However, this demands constructionally intricate steps.

The invention aims at providing a motor of the type set forth in the opening paragraph in which the reduction of the axial dimension of the iron stator body does not give rise to problems with respect to the linkage with the rotor-magnet flux. To this end the motor in accordance with the invention is characterized by Claim 1.

JP—A—552385 discloses a generator having an axial air-gap, which generator has some resemblance to the construction of the present motor, but does not have an axially magnetized ring adapted to the tooth surfaces and the stator coils.

Apart from the fact that this construction enables the axial dimension of the iron stator body to be reduced without a reduction of the effective stator-teeth area, this construction has the important advantage that the axially oriented air-gap field exerts an axial force on the rotor, enabling a thrust bearing to be used without taking additional steps. Another advantage of this construction is a greater choice as regards the magnet material because ring-shaped magnets are easier to manufacture. A preferred embodiment using this construction may yield even further advantages.

A first characteristic feature of the preferred embodiment is that at least two magnetic-field sensors are arranged between the stator limbs to cooperate directly with that part of the rotor magnet which cooperates with the tooth surfaces.

This has the advantage that the main rotor field

is utilized directly for driving the sensors, so that for example auxiliary magnets or magnet yoke constructions as employed in the motor in accordance with DE—OS 28 35 210 may be dispensed with.

A second characteristic feature of the preferred embodiment is that the stator is provided with a substantially flat support which is arranged transversely of the rotor shaft and which is secured to the iron body on that surface of said body which is situated axially opposite the said tooth surfaces, which support is formed with recesses for receiving parts of the stator windings which project from said surface of the iron body.

This simplifies the motor construction significantly, so that the cost price of the motor is reduced. The iron stator body can now be provided with the windings, after which it is secured to said support which has already been provided with the necessary connections and/or electronic components.

In this respect it is advantageous if the support is provided with printed circuitry and magnetic-field sensors, the electrical connections to the stator windings being made by means of said printed circuitry.

The printed circuitry enables the support to be provided with a meandering conductor track which cooperates with an auxiliary magnet system which can have been mounted on the rotor to generate a tacho signal.

As a result of this a tachogenerator is obtained in a very simple way, namely by providing said support with a printed conductor track. For producing a magnetic field for said meandering track it is advantageous that the rotor comprises a substantially disc-shaped support which is mounted substantially perpendicular on the shaft and which carries the annular magnet, and outside said annular magnet support changes into a cylindrical portion which carries a second annular magnet which constitutes said auxiliary magnet system which is situated radially outside the stator limbs.

The invention will now be described in more detail, by way of example, with reference to the drawings, in which:

Figures 1 and 2 are two sectional views of a known motor,

Figures 3, 4 and 5 are sectional views of a motor embodying the invention, and

Figures 6a and 6b show the connections to the stator coils in the motors shown in Figures 3, 4 and 5.

Figures 1 and 2 are sectional views of a known motor, Figure 1 being a sectional view taken on the line I—I' in Figure 2 and Figure 2 being a sectional view taken on the line II—II' in Figure 1. The stator comprises a star-shaped lamination assembly 1 with radial limbs 8, 9, 10, 11, 12 and 13 which terminate in stator-tooth surfaces 2, 3, 4, 5, 6 and 7, respectively which are disposed on an imaginary cylindrical surface. The limbs 8 to 13 carry windings 14 to 19, which project from both sides of the stator laminations. The iron stator

body is mounted on a support 20 which may be connected to, for example, a mounting plate.

The rotor comprises a shaft 22 which is mounted in the support 20 by means of a bearing 21. The shaft 22 is connected to a disc-shaped body 23 which changes into a cylindrical portion 25 which surrounds the stator and on its inner side has been provided with a cylindrical magnet 24 which is magnetized radially and which cooperates with the stator-tooth surfaces 2 to 7. The drawing shows on the sectional view the polarities of the rotor magnet on the inner surface of that magnet. In the present motor the rotor magnet has been provided with an 8-pole magnetization, the stator having 6 teeth and being of the three-phase type.

When the axial dimension of such a motor is to be reduced the problem arises that the surface area of the stator-tooth surfaces 2 to 7 which face the rotor magnet 24 becomes too small for an effective linkage with the rotor flux which issues from the rotor magnet, so that the rotor magnet cannot be utilized to an optimum extent. In the known motor in accordance with DE-OS 31 22 049 this problem is overcome by providing the stator teeth with flux conductors to increase the effective axial dimension of the tooth surfaces relative to the coil ends, which renders the stator construction intricate.

A satisfactory solution to this problem with some additional advantages is obtained by the use of the construction shown in Figures 3, 4 and 5 in which not the radial end faces of the stator limbs but the faces thereof which are situated outside the stator coils and which face in an axial direction are used as the tooth surfaces 2 to 7, so that the axial dimension of the iron stator body can be reduced to a limit imposed by saturation phenomena. Figure 3 is an axial sectional view taken on the line III-III' of Figures 4 and 5 and Figures 4 and 5 are two sectional views taken in opposite directions on the line IV-IV' (V-V') in Figure 3, Figure 5 showing the printed conductors. Corresponding parts bear the same reference numerals as in Figures 1 and 2, but the stator-tooth surfaces 2 to 7 now face in the axial direction of the iron stator body 1 and extend outside the stator coils 14 to 19. Instead of the cylindrical rotor magnet 24 in the motor of Figures 1 and 2 an annular magnet 26 is now mounted on the disc-shaped rotor support 23. This rotor magnet 26 is magnetized axially and cooperates with the stator-tooth surfaces 2 to 7 across an axial air gap. This magnet is mounted in the space adjacent the outwardly facing ends of the parts 31 of the windings 14 to 19 and in the present example also comprises 8 poles. As stated above, this solution enables the axial dimension of the motor to be reduced without the use of constructionally intricate steps. An important additional advantage is that the rotor magnet exerts an axial force on the stator iron, so that a rotor support 29 mounted on the rotor shaft is drawn against the bearing 21 (thrust bearing), which renders this motor suitable for use in

arbitrary positions (with respect to the direction of the force of gravity) without any additional steps. Moreover, it is substantially cheaper to construct the rotor magnet as a flat axially magnetized ring instead of a radially magnetized cylindrical ring, for example of axially prealigned sintered ferroxdure.

The use of an axially magnetized ring-shaped rotor magnet substantially simplifies the magnetization of this magnet. In such a construction it is simpler for example to make the separation between the poles depart from the radial line in order to reduce detent torques through a more gradual transition of the magnet poles across the gap between the stator poles.

The centre of the iron stator body 1 is connected to the bearing 21 and the far ends of the limbs to a support 28 (shown in more detail in Figure 5) via connections 32 to 37, for example metal or plastics pins, which support is constructed as a printed circuit board in which recesses are formed to accommodate the projecting parts 30 of the coils. In the present example this printed circuit board 28 has been provided with three contact faces 38, 39 and 40 in order to connect the stator coils in a star arrangement. Further, there are provided contacts 41, 42 and 43 for mounting Hall effect ICs 44, 45 and 46 (Figure 4). Via said p.c. board the contacts for the Hall effect ICs are connected to the coils and to power supply terminals 47 and 48.

When the coils are connected correctly and the number of stator teeth and rotor poles is correct, as in the configuration shown, commutation is effected when the relevant transition between the rotor magnet poles passes the transitions between the stator teeth. The Hall elements may then be arranged between these stator teeth and can be driven directly by the rotor main magnetic field, which is not possible with the known construction because Hall elements which are mounted directly on a support cannot be arranged in the rotor main magnetic field so that, as disclosed in for example DE-OS 28 35 210, an auxiliary yoke is required in order to conduct a part of the magnet flux to the Hall elements on the support or, as in the aforementioned Netherlands Patent Application 7908925, the Hall elements must be arranged in the stray field of the rotor magnet. Known motors also employ auxiliary magnets. When the Hall elements are arranged in the main field these elements will produce stronger signals so that the commutation instants are better defined.

The Hall elements are arranged at 120° electrically, i.e. in the present example between tooth surfaces 4 and 5, 5 and 6 (the same relative position with respect to the 8-pole magnet as between the tooth surfaces 2 and 3) and between the tooth surfaces 6 and 7. It is alternatively possible to use only two Hall elements because in a three-phase system the third phase can be found by vectorial addition of the two other phases.

If a configuration is used where commutation is

not effected upon passage of the transitions between the teeth by the transitions between the rotor poles or if it is not desirable to arrange the Hall elements between the tooth surfaces (for example in order to reduce the gaps between them), these elements may alternatively be arranged at a larger radial distance from the shaft 22 in such a way that by broadening them they yet cooperate with the rotor magnet 26.

Figure 6a shows the iron stator body 1 with the six coils, represented schematically, and Figure 6b shows the connections to the contacts 38, 39 and 40 required in order to obtain a star arrangement.

The drive by the Hall effect ICs may be such that a positive voltage appears on terminal 38 during 120° el., this terminal is floating during 60° el. (or is kept at a voltage between the two supply voltages), a negative voltage (or 0 V) appears on terminal 39 for 120° el., and subsequently it is floating for 60° el. (or carries half the supply voltage). The two other terminals 39 and 40 receive these driving voltages shifted through 120° el. and 240° el., respectively. For this purpose it is advantageous if the Hall effect ICs are equipped with an output which can carry both voltage levels and which can be floating.

For the generation of a tacho signal a meandering winding is arranged on the printed circuit board 28, which winding is connected to terminals 50 and 51. This winding is disposed in the field of a multi-pole auxiliary-magnet ring 27 which is arranged outside the stator on a circumferential flange on the cylindrical portion 25 of the rotor. In the present example the meandering winding covers only a part of the circumference in order to provide room for the printed circuitry for the electronics and the like.

Although the description relates to a three-phase version comprising 6 stator teeth and 8 rotor poles, the invention is not limited thereto. Other numbers of poles and teeth are possible, which also applies to the number of phases. Moreover, sensors other than Hall elements may be employed and various constructional details may be changed.

The motor described with reference to Figures 3 to 6 can be constructed very simply. The iron stator body may be stamped from sheet iron and provided with windings, after which the assembly may be mounted on the p.c. board, which has been equipped with the electronic components and tested, and the rotor is fitted.

Claims

1. An electric motor comprising a rotor which includes a permanent magnet and a stator which includes an iron body (1) which is coaxial with the rotor and which in an axial direction of the rotor is bounded by a substantially plane surface which extends substantially perpendicular to the rotor shaft (22), which iron body forms stator teeth which comprise radial limbs (8—13) which carry tooth surfaces (2—7) which cooperate with the

rotor, stator coils (14—19) being arranged around at least some of said limbs of the iron body and having outer and inner coil ends having end surfaces, whereby a part of each coil extends from the said plane surface in the said axial direction, characterized in that the tooth surfaces (1—7 — Figures 3, 4) which cooperate with the rotor (23, 26) are situated in a plane parallel to the said plane surface and cooperate with the rotor across an air gap in said axial direction, the rotor magnet comprising an axially magnetized permanent magnet ring (26) facing said tooth surfaces and extending axially and oppositely to the said axial direction into the space which is situated radially adjacent the outwardly facing coil ends, whereby the inner periphery of the permanent-magnetic ring (26) is situated radially adjacent and facing the surfaces of the outer coil ends.

2. An electric motor as claimed in Claim 1, in which the stator has three phases and six teeth, the rotor has six poles, and the stator windings (14—19) are connected in a three-phase star arrangement, characterized in that at least two magnetic-field sensors (44—46) are arranged between the stator limbs to cooperate directly with that part of the permanent magnetic ring (26) which cooperates with the tooth surfaces (2—7).

3. An electric motor as claimed in Claim 1 or 2, characterized in that the stator is provided with a substantially flat support (23) which is arranged substantially perpendicular to the rotor shaft (22) and which is situated axially opposite the said tooth surfaces (2—7), which support is formed with recesses for receiving parts of the stator coils (14—19) which project from said surface of the iron body (1).

4. An electric motor as claimed in Claim 3, characterized in that said support (23) is provided with printed circuitry and magnetic-field sensors (44—46) the electrical connections to the stator coils (14—19) being made by means of said printed circuitry.

5. An electric motor as claimed in Claim 4, characterized in that the support (23) is provided with a meandering conductor track (49) which cooperates with a auxiliary magnet system which has been mounted on the rotor to generate a tacho signal.

6. An electric motor as claimed in Claim 5, characterized in that the rotor comprises a substantially disc-shaped support (23) which is mounted transversely on the shaft (22) and which carries the permanent magnetic ring (26), and outside said ring said support changes into a cylindrical portion (25) which carries a auxiliary-magnet ring (27) which constitutes said auxiliary magnet system which is situated radially outside the stator limbs.

Patentansprüche

1. Elektromotor mit einem Läufer mit einem Dauermagneten und mit einem Ständer mit einem zu dem Läufer koaxialen und in einer

not effected upon passage of the transitions between the teeth by the transitions between the rotor poles or if it is not desirable to arrange the Hall elements between the tooth surfaces (for example in order to reduce the gaps between them), these elements may alternatively be arranged at a larger radial distance from the shaft 22 in such a way that by broadening them they yet cooperate with the rotor magnet 26.

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Although the description relates to a three-phase version comprising 6 stator teeth and 8 rotor poles, the invention is not limited thereto. Other numbers of poles and teeth are possible, which also applies to the number of phases. Moreover, sensors other than Hall elements may be employed and various constructional details may be changed.

The motor described with reference to Figures 3 to 6 can be constructed very simply. The iron stator body may be stamped from sheet iron and provided with windings, after which the assembly may be mounted on the p.c. board, which has been equipped with the electronic components and tested, and the rotor is fitted.

Claims

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rotor, stator coils (14—19) being arranged around at least some of said limbs of the iron body and having outer and inner coil ends having end surfaces, whereby a part of each coil extends from the said plane surface in the said axial direction, characterized in that the tooth surfaces (1—7 — Figures 3, 4) which cooperate with the rotor (23, 26) are situated in a plane parallel to the said plane surface and cooperate with the rotor across an air gap in said axial direction, the rotor magnet comprising an axially magnetized permanent magnet ring (26) facing said tooth surfaces and extending axially and oppositely to the said axial direction into the space which is situated radially adjacent the outwardly facing coil ends, whereby the inner periphery of the permanent-magnetic ring (26) is situated radially adjacent and facing the surfaces of the outer coil ends.

2. An electric motor as claimed in Claim 1, in which the stator has three phases and six teeth, the rotor has six poles, and the stator windings (14—19) are connected in a three-phase star arrangement, characterized in that at least two magnetic-field sensors (44—46) are arranged between the stator limbs to cooperate directly with that part of the permanent magnetic ring (26) which cooperates with the tooth surfaces (2—7).

3. An electric motor as claimed in Claim 1 or 2, characterized in that the stator is provided with a substantially flat support (23) which is arranged substantially perpendicular to the rotor shaft (22) and which is situated axially opposite the said tooth surfaces (2—7), which support is formed with recesses for receiving parts of the stator coils (14—19) which project from said surface of the iron body (1).

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6. An electric motor as claimed in Claim 5, characterized in that the rotor comprises a substantially disc-shaped support (23) which is mounted transversely on the shaft (22) and which carries the permanent magnetic ring (26), and outside said ring said support changes into a cylindrical portion (25) which carries a auxiliary-magnet ring (27) which constitutes said auxiliary magnet system which is situated radially outside the stator limbs.

Patentansprüche

1. Elektromotor mit einem Läufer mit einem Dauermagneten und mit einem Ständer mit einem zu dem Läufer coaxialen und in einer



axialen Richtung des Läufers durch eine im wesentlichen ebene Fläche quer zu der Läuferachse (22) begrenzten Eisenkörper (1), der Ständerzähne bildet, die radiale Glieder (8—13) aufweisen, die mit dem Läufer zusammenarbeitende Zahnflächen (2—7) haben, wobei um wenigstens einige dieser Glieder des Eisenkörpers Ständerspulen (14—19) vorgesehen sind mit äusseren und inneren Spulenenden mit Endflächen, wobei ein Teil jeder Spule sich von der genannten ebenen Fläche in der genannten axialen Richtung erstreckt, dadurch gekennzeichnet, dass die Zahnflächen (2 bis 7, Fig. 3, 4), die mit dem Läufer (23, 26) zusammenarbeiten, in einer Ebene liegen, die sich parallel zu der genannten ebenen Fläche erstreckt und über einen Luftspalt in der genannten axialen Richtung mit dem Läufer zusammenarbeitet, wobei der Läufermagnet einen axial magnetisierten Dauermagnetring (26) aufweist, der den genannten Zahnflächen zugewandt ist und sich axial und entgegen der genannten axialen Richtung in denjenigen Raum erstreckt, der sich radial neben den äusseren Spulenenden befindet, wobei der Innenrand des Dauermagnetringes (26) radial neben den Flächen der äusseren Spulenenden liegt und denselben zugewandt ist.

2. Elektromotor nach Anspruch 1, wobei der Ständer drei Phasen und sechs Zähne aufweist, wobei der Läufer sechs Pole hat und die Ständerwicklungen (14—19) in einer Dreiphasensternwicklung angeordnet sind, dadurch gekennzeichnet, dass wenigstens zwei Magnetfeldsensoren (44—46) zwischen den Ständerschenkeln vorgesehen sind und zwar zum unmittelbaren Zusammenarbeiten mit demjenigen Teil des Dauermagnetringes (26), der mit den Zahnflächen (2—7) zusammenarbeitet.

3. Elektromotor nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass der Ständer mit einem im wesentlichen flachen Träger (23) versehen ist, der nahezu senkrecht zu der Läuferachse (22) angeordnet ist und axial gegenüber den genannten Zahnflächen (2—7) liegt, wobei dieser Träger mit Ausnehmungen versehen ist zum Aufnehmen von Teilen der Ständerspulen (14—19), die von der genannten Fläche des Eisenkörpers (1) vorspringen.

4. Elektromotor nach Anspruch 3, dadurch gekennzeichnet, dass der Träger (23) mit einer gedruckten Schaltungsanordnung und Magnetfeldsensoren (44—46) versehen ist, wobei die elektrischen Verbindungen mit den Ständerspulen (14—19) mittels der genannten gedruckten Schaltungsanordnung gebildet werden.

5. Elektromotor nach Anspruch 4, dadurch gekennzeichnet, dass der Träger (23) mit einer meanderförmigen Leiterspule (49) versehen ist, die mit einem Hilfsmagnetsystem zusammenarbeitet, das zum Erzeugen eines Tachosignals auf dem Läufer angeordnet ist.

6. Elektromotor nach Anspruch 5, dadurch gekennzeichnet, dass der Läufer eine im wesentlichen scheibenförmigen Träger (23) aufweist, der quer zu der Achse (22) angeordnet ist und der den

Dauermagnetring (26) trägt und wobei ausserhalb dieses Ringes der Träger in einen zylinderförmigen Teil (25) übergeht, der einen Hilfsmagnetring (27) aufweist, der das genannte Hilfsmagnetsystem bildet, das radial ausserhalb der Ständerschenkel liegt.

Revendications

1. Moteur électrique comportant un rotor muni d'un aimant permanent et un stator muni d'un corps de fer (1) qui est coaxial avec le rotor et qui, dans une direction axiale du rotor, est limité par une surface sensiblement plane s'étendant sensiblement perpendiculairement à l'arbre (22) du rotor, corps de fer qui forme des dents statoriques comportant des branches radiales (8—13) portant des surfaces de dent (2—7) qui coopèrent avec le rotor, des bobines statoriques (14—19) étant disposées au moins autour de quelques-unes desdites branches du corps de fer, bobines statoriques qui présentent des extrémités extérieure et intérieure ayant des surfaces terminales, une partie de chaque bobine s'étendant à partir de ladite surface plane dans ladite direction axiale, caractérisé en ce que les surfaces de dent (2—7 — figures 3, 4) coopèrent avec le rotor (23, 26) sont situées dans un plan parallèle à ladite surface plane et coopèrent avec le rotor à travers un entrefer dans ladite direction axiale, l'aimant rotorique comportant un anneau magnétique permanent à aimantation axiale (26) situé vis-à-vis desdites surfaces de dent et s'étendant axialement et à l'opposé de ladite direction axiale jusque dans l'espace situé radialement à côté des extrémités de bobine regardant vers l'extérieur, étant étendu que la périphérie intérieure de l'anneau magnétique permanent (26) est située radialement à côté des surfaces des extrémités de bobine extérieures et vis-à-vis de ces surfaces.

2. Moteur électriques selon la revendication 1, dans lequel le stator a trois phases et six dents, le rotor a six pôles et les enroulements statoriques (14—19) sont connectés en montage en étoile triphasée, caractérisé en ce qu'au moins deux capteurs de champ magnétique (44—46) sont disposés entre les branches statoriques pour coopérer directement avec la partie de l'anneau magnétique permanent (26), coopérant avec les surfaces de dent (2—7).

3. Moteur électrique selon la revendication 1 ou 2, caractérisé en ce que le stator est muni d'un support sensiblement plat (23) disposé sensiblement perpendiculairement à l'arbre de rotor (22) et situé axialement vis-à-vis desdites surfaces de dent (2—7), support qui présente des évidements pour recevoir des parties des bobines statoriques (14—19), faisant saillie de ladite surface du corps de fer (1).

4. Moteur électrique selon la revendication 3, caractérisé en ce que ledit support (23) est muni d'un câblage imprimé et de capteurs de champ magnétique (44—46), les liaisons électriques aux bobines statoriques (14—19) étant établies au moyen dudit câblage imprimé.



5. Moteur électrique selon la revendication 4, caractérisé en ce que le support (23) est muni d'une piste conductrice en zigzag (49) coopérant avec un système magnétique auxiliaire, monté sur le rotor, pour engendrer un signal tachymétrique.

6. Moteur électrique selon la revendication 5, caractérisé en ce que le rotor comporte un sup-

port sensiblement en forme de disque (23) disposé transversalement à l'arbre (22) et portant l'anneau magnétique permanent (26) et en ce que, à l'extérieur dudit anneau, ledit support présente une partie cylindrique (25) portant un anneau magnétique auxiliaire (27) qui constitue ledit système magnétique auxiliaire situé radialement à l'extérieure des branches statoriques.

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