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Datasheet for the decision of 24 October 2007

Case Number: T 0820/05 - 3.5.02

Application Number: 00988053.5

Publication Number: 1219007

IPC: H02K 1/27

Language of the proceedings: EN

Title of invention:
Brushless motor with reduced rotor inertia

Applicant:
Delphi Technologies, Inc.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step -no"

Decisions cited:
-

Headnote:
See point 4 of the Reasons

Case Number: T 0820/05 - 3.5.02

D E C I S I O N
of the Technical Board of Appeal 3.5.02
of 24 October 2007

Appellant: Delphi Technologies, Inc.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 15 December 2004 refusing European application No. 00988053.5 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: M. Ruggiu
Members: G. Flyng
E. Lachacinski

Summary of Facts and Submissions

I. The applicant appealed against the decision of the examining division refusing the European patent application No. 00 988 053.5.

II. In the contested decision, the examining division found in particular that the subject-matter of claim 1 did not involve an inventive step in view of the prior art disclosed in the following documents:

D1: US-A-2 974 242 and

D5: US-A-5 041 749.

III. Oral proceedings were held before the board on 24 October 2007. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of claims 1 to 3 that had been filed with a letter dated 10 September 2007.

IV. Claim 1 reads as follows:

"A direct current electric motor (20), said motor comprising:
a housing (22);
a stator (34) affixed to the housing, the stator comprising a plurality of electrically conductive windings and further defining a central cavity; and
a rotor (36) mounted within the central cavity, the rotor comprising
a rotor shaft (30);
a pair of spaced end caps (38) on the shaft;

a magnet ring (40) rotationally coupled to the rotor shaft (30) and radially spaced therefrom by the end caps (38); and
a rotor core (46) disposed about the shaft;
wherein the magnet ring (40) comprises a plurality of permanent magnets (52, 54); and
wherein the permanent magnets (52, 54) extend between the end caps and abut one another to define a cylindrical inner surface;
characterised in that the end caps (38) are secured to the shaft;
in that the rotor shaft (30), the end caps (38) and the magnet ring (40) define an annular cavity;
in that the rotor core (46) is mounted within the annular cavity and is rotationally de-coupled from the shaft, the end caps and the magnet ring, and rotatably supported by the shaft in radially spaced relationship to the magnet ring for rotation relative to the magnet ring; and
in that the magnetic polarity of adjacent magnets is different with permanent magnet north pole magnets being separated by permanent magnet south pole magnets; such that the motor has a reduced inertia rotor."

Claims 2 and 3 are dependent on claim 1.

V. The appellant's arguments relevant to the present decision may be summarised as follows:

Document D5 did not disclose an arrangement of magnets in which "the magnetic polarity of adjacent magnets was different with permanent magnet north pole magnets being separated by permanent magnet south pole magnets" as set out in claim 1.

A skilled person would not attempt to combine document D5 with document D1 because the underlying physical operation of the two motors was completely different. Specifically, document D5 disclosed a permanent magnet brushless motor, whereas D1 disclosed an induction motor.

Reasons for the Decision

1. The appeal is admissible.

2. As regards the interpretation of the feature of claim 1 that "the magnetic polarity of adjacent magnets is different with permanent magnet north pole magnets being separated by permanent magnet south pole magnets", the board has taken into account the content of the application as published (WO 01/45237 A1), in particular figure 4 and page 6, lines 19 to 23 thereof. Figure 4 shows flux lines which:

- enter the magnet 54 at the outer periphery of the permanent magnet ring 40,
- pass substantially radially through the magnet 54,
- leave the magnet 54 at the inner periphery of the permanent magnet ring 40,
- pass across the air gap 50 to the rotor core 46,
- pass through the rotor core 46,
- leave the rotor core and pass across the air gap 50 to the magnet 52 at the inner periphery of the permanent magnet ring 40,
- pass substantially radially through the magnet 52, and

– exit the magnet 52 at the outer periphery of the permanent magnet ring 40.

According to the conventions set out in page 6, lines 19 to 23 of the application, the flux lines indicated in figure 4 are such that the magnet 52 presents not only a north pole on its outer periphery as stated, but also a south pole on its inner periphery. Furthermore, the magnet 54 would present not only a south pole on its outer periphery as stated, but also a north pole on its inner periphery. With this in mind, "permanent magnet north pole magnets" are construed in the present context as meaning magnets which present a north pole on their outer periphery and "permanent magnet south pole magnets" are construed in the present context as meaning magnets which present a south pole on their outer periphery.

3. Present claim 1 concerns a direct current electric motor with a rotor having a magnet ring comprising a plurality of permanent magnets. The application as filed states at page 2, lines 23 to 27 that in such motors "*the rotors generally comprise a shaft upon which is mounted a high-density magnetic core with a plurality of permanent magnets affixed about its periphery. The large mass of the rotor results in a large rotational inertia, which is then difficult to reverse or cycle at the desired high cycling rates*". Document D5, which was referred to in the decision under appeal, discloses a DC motor having a rotor which has this same basic structure of a shaft 20, a laminated magnetic core 16 and a permanent magnet ring 12 (column 3, lines 47 to 63 and figures 1 and 2). The board considers that, when using the problem and

solution approach to assess inventive step in the present case, document D5 is a more appropriate starting point than document D1, because the motor disclosed in D5 is of the same basic type as that in the present application and, furthermore, because such a permanent magnet DC motor would be more suitable for the desired use (computer controlled applications in vehicles) than an induction motor as disclosed in D1.

4. Document D5 discloses a direct current electric motor 10 comprising:
a housing 30a, 30b, 31 (column 5, lines 52 to 56);
a stator 22 affixed to the housing (column 5, lines 54 to 61), the stator comprising a plurality of electrically conductive windings 38 (column 4, lines 56 to 58) and further defining a central cavity 26 ("inner diameter edge" column 4, lines 7 to 10); and
a rotor 11 mounted within the central cavity (figures 1 and 2), the rotor comprising:
a rotor shaft 20 (column 3, lines 60 and 61);
a pair of spaced end caps 60a, 60b on the shaft (column 5, lines 62 to 68);
a rotor core 16 disposed about the shaft 20 (column 3, lines 57 to 61); and
a magnet ring 12 (column 3, lines 49 to 52) rotationally coupled to the rotor shaft and radially spaced therefrom by the end caps 60a, 60b, fastening means 61a, 61b and the rotor core 16 (column 5, lines 62 to 68 and column 3, lines 60 and 61).
The magnet ring 12 comprises a plurality of permanent magnets which extend between the end caps and abut one another to define a cylindrical inner surface 14 (column 3, lines 49 to 54; figure 9).

The magnetic polarity of adjacent magnets is different, with magnets which present a north pole on their outer periphery ("north pole magnets") being separated by magnets which present a south pole on their outer periphery ("south pole magnets") (figure 2).

5. The subject-matter of present claim 1 differs from the disclosure of document D5 in that:

– the end caps are secured to the shaft;
– the rotor shaft, the end caps and the magnet ring define an annular cavity;
– the rotor core is mounted within the annular cavity;
– the rotor core is rotationally de-coupled from the shaft, the end caps and the magnet ring, and rotatably supported by the shaft in radially spaced relationship to the magnet ring for rotation relative to the magnet ring;
– such that the motor has a reduced inertia rotor.

6. These novel features of claim 1 have the technical effect of reducing the rotational inertia of the rotor to facilitate rapid control cycling (cf. page 2, lines 27 to 29 of the present application as published). The objective problem to be solved may therefore be considered to be to reduce the inertia of the rotor.

7. Document D1 discloses a motor having a high torque/inertia ratio capable of extremely fast starting and reversing (see column 1, lines 20, 21 and 45 to 48). D1 indicates that previous attempts to provide a high torque/inertia ratio have been made using hollow rotors of conductive material ... having a free-running internal cylinder to complete the magnetic circuit

(column 1, lines 24 to 28). However materials previously used for the hollow rotor (rotor sleeve) have resulted in little improvement in the torque/inertia ratio (column 1, lines 28 to 44). D1 achieves its object by a freely rotatable ferromagnetic core disposed between the rotor shaft and a thin, lightweight, low resistance sleeve having magnetic inserts embedded therein (column 1, lines 49 to 53). The ferromagnetic core 6 is rotatably mounted on the rotor shaft via bearings 9 (column 2, lines 19 to 29). The sleeve is a cylindrical conductive metallic shell 10 and is connected to the rotor shaft by circular plate members 11 (column 2, lines 41 to 45). The sleeve 10 is provided with slots 18 in which inserts or bars 19 are embedded (column 3, lines 23 to 26). The inserts are of ferromagnetic material (column 3, lines 54 to 56). The motor functions as an induction motor (see title), with the rotating stator magnetic field inducing electrical currents in the shell 10, thereby imparting rotation to the shell (column 3, lines 1 to 4). Thus, the basic motor type disclosed in D1 (induction motor) is indeed different to that used in the present application, which is a permanent magnet brushless DC motor.

8. The board considers, however, that the skilled person would recognise from the disclosure of document D1 that the reduction in inertia is achieved by rotationally de-coupling the magnetic core from the remaining parts of the rotor, i.e. the shaft and the torque producing rotor bars 19. Seeking to apply this principle to the permanent magnet DC motor of document D5, it would be obvious to the skilled person to rotationally de-couple the rotor core (back iron) from the permanent magnet

ring. The skilled person would recognise that the permanent magnet ring would then need to be supported from the shaft and would achieve this using the mounting structure disclosed in document D1. The board therefore considers that the skilled person would come to the subject-matter of claim 1 without involving an inventive step, Article 56 EPC.

Order

For the above reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

U. Bultmann M. Ruggiu