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# (54) A magnetizing method and its apparatus

Magnetisierungsverfahren und seine Vorrichtung

Procédé de magnétisation et son appareil

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(56) References cited:
**WO-A2-2012/089217** **GB-A- 530 779**



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## Description

### Technical field

**[0001]** the present invention relates to needle textile field, and especially, to a magnetizing method and its apparatus.

### Background Art

**[0002]** There are several solenoids arranged side by side in the actuator of the knitting machine, and a magnetic field reversible permanent magnet is inserted in each solenoid. There is a permanent magnet provided at one end of the solenoid, and the permanent magnet connects with a tool bit. After the solenoid is powered on, a magnetic field is formed in the solenoid to magnetize the magnetic field reversible permanent magnet, viz. magnetize the magnetic field reversible permanent magnet in the solenoid. When the magnetic field in the solenoid reaches a rated magnetic field intensity, the magnetism of the magnetic field reversible permanent magnet reaches a preset magnetic field intensity, at this moment, acting force is produced between the magnetic field reversible permanent magnet and the permanent magnet to cause the permanent magnet at one end of the solenoid to move and then couple the tool bit on the permanent magnet, achieving needle selection.

**[0003]** However, in the traditional actuator, the magnetizing time of the solenoid is about 1ms~2ms, it needs longer magnetizing time for the magnetic field reversible permanent magnet to reach the preset magnetic field intensity when magnetizing the magnetic field reversible permanent magnet inside the solenoid. A device for magnetizing a rotor of an electrical machine with a power rating of at least 1 MW is known from WO 2012/089217 A2.

### Contents of the invention

**[0004]** This present invention provides a magnetizing method and its apparatus which can shorten the magnetizing time of the solenoid. It is clear that the inventive magnetizing method can be defined by the specific function of the inventive apparatus. Further, the inventive magnetizing apparatus can work according to the function of the method steps of the inventive magnetizing method.

**[0005]** For this purpose, the technical solution of the invention is implemented as follows:

A magnetizing method includes:

Apply a preset magnetizing voltage to a solenoid of a preset turn number, the preset magnetizing voltage is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid;
Magnetize the magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid.

Preferably, before applying the preset magnetizing voltage to the solenoid of the preset turn number, the method also includes:

Set the ampere turns of the solenoid;
Obtain the peak magnetizing current of the solenoid according to the ampere turns of the solenoid, and the corresponding relation between the turn number and the magnetizing current;
Obtain the preset magnetizing voltage according to the peak magnetizing current and the DC resistance of the solenoid.

Furthermore, the method also includes:

Obtain the preset residual magnetism kept by the magnetic field reversible permanent magnet when the magnetizing current of the solenoid is cut off, according to the ampere turns of the solenoid and the corresponding relation between the ampere turns and residual magnetism;
The magnetic field reversible permanent magnet produces acting force with the permanent magnet at one end of the solenoid under the action of the preset residual magnetism to couple the tool bit on the permanent magnet.
Preferably,
The preset magnetizing voltage is more than or equal to 3 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid.
Preferably,

The preset magnetizing voltage is more than or equal to 5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid.

Preferably, the preset turn number of the solenoid is 533, the DC resistance of the solenoid is 6.3Ω, and the peak magnetizing current of the solenoid is 1.65A;

The preset magnetizing voltage is 30.5V.

Preferably, the preset turn number of the solenoid is 533, the DC resistance of the solenoid is 6.3Ω, and the peak magnetizing current of the solenoid is 1.65A;

The preset magnetizing voltage is 61V.

The present invention also provides a magnetizing apparatus, which includes:

A voltage supply module for applying a preset magnetizing voltage to a solenoid of a preset turn number, and the preset magnetizing voltage is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid;

A magnetizing module for magnetizing the magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid.

Furthermore, the apparatus also includes:

A setting module for setting the ampere turns of the solenoid;

A current module for obtaining the peak magnetizing current of the solenoid according to the ampere turns of the solenoid, and the corresponding relation between the turn number and the magnetizing current;

A voltage module for calculating the preset magnetizing voltage according to the peak magnetizing current and the DC resistance of the solenoid.

Furthermore, the apparatus also includes:

A residual magnetism module for calculating the preset residual magnetism kept by magnetic field reversible permanent magnet when the magnetizing current of the solenoid is cut off, according to the ampere turns of the solenoid and the corresponding relation between the ampere turns and the residual magnetism;

A couple module for producing acting force with the permanent magnet at one end of the solenoid under the action of the preset residual magnetism to couple the tool bit on the permanent magnet.

To compare with the existing technology, in the magnetizing method and its apparatus of the present invention, the preset magnetizing voltage of the solenoid is more than or equal to the 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, which is different from the existing technology, where generally the magnetizing voltage of the solenoid is equal to the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid. It can be seen from the experimental data, the magnetizing method and its apparatus of the present invention can shorten the magnetizing time of the solenoid effectively.

In addition, the following positive effects can also be obtained through the magnetizing method and its apparatus of the present invention:

1. Because the shorten of the magnetizing time, the magnetic field reversible permanent magnet can reach the preset magnetic field intensity in short time, thereby produce acting force with the permanent magnet at one end of the solenoid, draw the permanent magnet and then couple the tool bit on the permanent magnet, viz. shorten the response time of the tool bit;

2. Because the preset magnetizing intensity of the solenoid is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, which is different from the existing technology, where generally the magnetizing voltage of the solenoid is equal to the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid. It can be seen from the experimental data, the magnetizing method and its apparatus of the present invention can reduce the magnetizing energy consumption of the solenoid effectively.

## Description of figures

**[0006]** In order to describe the embodiments of the present invention or the technical solution of the existing technology clearly, the embodiments or the figures necessary for the description of the existing technology are introduced briefly

hereinafter. Obviously, the figures described hereinafter are some embodiments of the present invention, the common technicians in the field may obtain other figures according to those figures without any creative work.

Fig. 1 is a flow chart of a magnetizing method provided by embodiment 1 of the present invention;
Fig. 2 is a flow chart of another magnetizing method provided by embodiment 2 of the present invention;
Fig. 3 is a block diagram of a magnetizing apparatus provided by embodiment 3 of the present invention;
Fig. 4 is a block diagram of another magnetizing apparatus provided by embodiment 4 of the present invention.

**Mode of Carrying out the Invention**

**[0007]** In order to show the purpose, the technical solution and the advantages of the embodiments of the present invention more clearly, hereinafter the technical solutions in the embodiments of the present invention will be described clearly and completely in conjunction with the figures in the embodiments of the present invention. Apparently, the embodiments described herein are only partial embodiments of the present invention, but not all of them. Based on the embodiments of the present invention, all other embodiments obtained by the common technicians in the art without any creative work are within the protecting range of the present invention.

Embodiment 1

**[0008]** The embodiment of the present invention provides a magnetizing method, refer to Fig. 1, which includes:

Step S101: apply a preset magnetizing voltage to the solenoid of a preset turn number, the preset magnetizing voltage is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid;
Wherein, the preset magnetizing voltage refers to the DC voltage component applied on both ends of the solenoid during one magnetizing cycle;
Step S102: magnetize magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid.

**[0009]** In the magnetizing method provided by embodiment 1 of the present invention, the preset magnetizing voltage of the solenoid is more than or equal to the 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, which is different from the existing technology, where generally the magnetizing voltage of the solenoid is equal to the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid. It can be seen from the experimental data, the magnetizing method provided by the present invention can shorten the magnetizing time of the solenoid effectively.

Embodiment 2

**[0010]** Embodiment 2 of the present invention provides another magnetizing method. This method takes the actuator of the knitting machine as an example, refer to Fig. 2, which includes:

Step 201: set the ampere turns of the solenoid;
Wherein, the ampere turns of the solenoid is the representation of the magnetic field intensity, viz. the product of the turn number of the solenoid and the peak magnetizing current of the solenoid;
Step 202: obtain the peak magnetizing current of the solenoid according to the ampere turns of the solenoid, and the corresponding relation between the turn number and the magnetizing current;
Step 203: obtain the preset magnetizing voltage according to the peak magnetizing current and the DC resistance of the solenoid;
Step 204: apply the preset magnetizing voltage to the solenoid of the preset turn number;
Wherein, the preset magnetizing voltage is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid;
In detail, in this embodiment, the preset magnetizing voltage is more than or equal to 3 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid;
Or, furthermore, the preset magnetizing voltage is more than or equal to 5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid;
For instance, 1) the preset turn number of the solenoid is 533, the DC resistance of the solenoid is 6.3Ω, and the peak magnetizing current of the solenoid is 1.65A;
Accordingly, the preset magnetizing voltage is 30.5V;

Or, 2) the preset turn number of the solenoid is 533, the DC resistance of the solenoid is 6.3Ω, and the peak magnetizing current of the solenoid is 1.65A;
Accordingly, the preset magnetizing voltage is 61V;
Step 205: magnetize the magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid.
Step 206: obtain the preset residual magnetism kept by the magnetic field reversible permanent magnet when the magnetizing current of the solenoid is cut off, according to the ampere turns of the solenoid and the corresponding relation between the ampere turns and residual magnetism;
Wherein, the residual magnetism is the preset residual magnetism kept by the magnetic field reversible permanent magnet when the magnetizing current of the solenoid is 0;
In detail, in this embodiment, when the ampere turns of the solenoid is the product of 553 turns and 1.65A, obtain the preset residual magnetism kept by the magnetic field reversible permanent magnet is 720 Gs, according to the corresponding relation between the ampere turns and residual magnetism;
Step 207: produce acting force with the permanent magnet at one end of the solenoid under the action of the preset residual magnetism of the magnetic field reversible permanent magnet, to couple the tool bit on the permanent magnet.

Experimental data:

Relationships among voltage, time and energy consumption

**[0011]**

| Preset magnetizing voltage of solenoid (V) | magnetizing time of solenoid (μs) | Magnetizing energy consumption of solenoid (mj) |
|---|---|---|
| 13.3 | 1600 | 28.7 |
| 20 | 600 | 13.6 |
| 30.5 | 336 | 12.2 |
| 61 | 147 | 11.9 |

**[0012]** Wherein, the preset magnetizing voltage of the solenoid in the traditional actuator is 13.3V, accordingly, the magnetizing time of the solenoid is 1600μs, viz. the interval from zero current of the solenoid to the peak magnetizing current is 1600μs, and the magnetizing energy consumption of the solenoid is 28.7mj, this magnetizing energy consumption is the sum of the power loss of the solenoid coil and the energy loss caused by magnetic absorption of the magnetic field reversible permanent magnet.
It can be seen from the above table, as the preset magnetizing voltage of the solenoid increases gradually, the reduction of magnetizing energy consumption of solenoid slows down and flatten gradually, because when the preset magnetizing voltage is high, the power loss consumed by the solenoid coil tends to be a stable value gradually, the stable value is small. While the energy loss caused by magnetic absorption of the magnetic field reversible permanent magnet is a fixed value, which is about 11mj. In this way, the power loss caused by the solenoid coil is a very small value in relation to the energy loss caused by magnetic absorption of the magnetic field reversible permanent magnet. Therefore, as the preset magnetizing voltage of the solenoid increases, the power loss has small influence to the whole magnetizing energy consumption of the solenoid, and the magnetizing energy consumption of the solenoid tends to be the above fixed value.
**[0013]** Besides, generally the magnetizing time of the solenoid is more than 40μs. If the magnetizing time is less, all current passing through a conductor concentrates on the surface of the conductor, and the eddy-current loss of the magnetic field reversible permanent magnet increases, thereby the magnetizing energy consumption of the solenoid increases.
In this way, in this embodiment, the preset magnetizing voltage of the solenoid is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, or furthermore, the preset magnetizing voltage of the solenoid is more than or equal to 3 or 5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, which is different from the existing technology, where generally the magnetizing voltage of the solenoid is equal to the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid. It can be seen from the experimental data, the magnetizing method provided by the present invention can shorten the magnetizing time of the solenoid effectively.

In addition, because of the shorten of the magnetizing time, the magnetic field reversible permanent magnet is caused to reach the preset magnetic field intensity in short time, thereby generate acting force with the permanent magnet at one end of the solenoid, draw the permanent magnet and then couple the tool bit on the permanent magnet, viz. shorten the response time of the tool bit;

At the same time, because the preset magnetizing intensity of the solenoid is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, which is different from the existing technology, where generally the magnetizing voltage of the solenoid is equal to the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid. It can be seen from the experimental data, the magnetizing method provided by the present invention can reduce the magnetizing energy consumption of the solenoid effectively.

Furthermore, besides the actuator, the magnetizing method provided in embodiment 2 of the present invention can also be applicable to the other apparatus that adopt electromagnetic induction or the magnetic actuator, such as the solenoid valve and the relay.

Embodiment 3

Embodiment 3 of the present invention provides one magnetizing apparatus for embodiment 1, refer to Fig. 3, which includes:

**[0014]** A voltage supply module 31 for applying a preset magnetizing voltage to a solenoid of a preset turn number, and the preset magnetizing voltage is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid;

A magnetizing module 32 for magnetizing the magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid.

In the magnetizing apparatus provided by the embodiment of the present invention, the preset magnetizing voltage of the solenoid is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, or furthermore, the preset magnetizing voltage of the solenoid is more than or equal to 3 or 5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, which is different from the existing technology, where generally the magnetizing voltage of the solenoid is equal to the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid. It can be seen from the experimental data, the magnetizing apparatus provided by the present invention can reduce the magnetizing time of the solenoid effectively.

Embodiment 4

**[0015]** Embodiment 4 of the present invention provides another magnetizing apparatus for embodiment 2, the magnetizing apparatus is applied to the actuator of a knitting machine. There are several solenoids arranged side by side in the actuator, and a magnetic field reversible permanent magnet is inserted in each solenoid; the permanent magnets are alternately arranged at one end of the magnetic field reversible permanent magnet, and each permanent magnet is connected with a tool bit, the tool bit is the needle head of the actuator. Refer to Fig. 4, the magnetizing apparatus includes:

A setting module 41 for setting the ampere turns of the solenoid;

A current module 42 for obtaining the peak magnetizing current of the solenoid according to the ampere turns of the solenoid, and the corresponding relation between the turn number and the magnetizing current;

A voltage module 43 for calculating the preset magnetizing voltage according to the peak magnetizing current and the DC resistance of the solenoid.

**[0016]** A voltage supply module 44 for applying a preset magnetizing voltage to the solenoid of a preset turn number;

Wherein, the preset magnetizing voltage is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid;

In detail, in the embodiment, the preset magnetizing voltage is more than or equal to 3 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid.

Or, furthermore, the preset magnetizing voltage is more than or equal to 5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid.

A magnetizing module 45 for magnetizing the magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid.

A residual magnetism module 46 for calculating the preset residual magnetism kept by the magnetic field reversible permanent magnet when the magnetizing current of the solenoid is cut off, according to the ampere turns of the solenoid

and the corresponding relation between the ampere turns and residual magnetism;
A couple module 47 for producing acting force with the permanent magnet at one end of the solenoid under the action of the preset residual magnetism of magnetic field reversible permanent magnet to couple the tool bit on the permanent magnet.

**[0017]** In this way, in the embodiment, the preset magnetizing voltage of the solenoid is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, or furthermore, the preset magnetizing voltage of the solenoid is more than or equal to 3 or 5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, which is different from the existing technology, where generally the magnetizing voltage of the solenoid is equal to the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid. It can be seen from the experimental data, the magnetizing apparatus provided by the present invention can shorten the magnetizing time of the solenoid effectively.

**[0018]** In addition, because of the shorten of the magnetizing time, the magnetic field reversible permanent magnet can reach the preset magnetic field intensity in short time, thereby generate acting force with the permanent magnet at one end of the solenoid, draw the permanent magnet and then couple the tool bit on the permanent magnet, viz. shorten the response time of the tool bit;
At the same time, because the preset magnetizing intensity of the solenoid is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid, which is different from the existing technology, where generally the magnetizing voltage of the solenoid is equal to the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid. It can be seen from the experimental data, the magnetizing apparatus provided by the present invention can reduce the magnetizing energy consumption of the solenoid effectively.

**[0019]** Furthermore, performing multi-strand parallel winding to the winding of the above mentioned solenoid of the preset turn number, adding or reducing turns of the winding, making DC component equivalent transformation to the magnetizing voltage and so on are also allowed.

**[0020]** The last shall be noted that: the above-mentioned embodiments are only for illustrating the technical solution of the invention, not for limiting it; though the present invention has been described with the above-mentioned embodiments, the common technicians in the field should understand that: they can still modify the technical solution recorded in each embodiment above-mentioned, or make equivalent replacement to partial technical features of it; while those modifications and replacements will not cause the essence of the corresponding technical solution to depart from the scope of the technical solution of individual embodiment of the present invention.

## Claims

1. A magnetizing method, which is **characterized by**
applying a preset magnetizing voltage to a solenoid of a preset turn number, the preset magnetizing voltage being more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid (S101);
magnetizing the magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid (S102);
obtaining a preset residual magnetism of the magnetic field reversible permanent magnet when the magnetizing current of the solenoid is cut off, according to the ampere turns of the solenoid and the corresponding relation between the ampere turns and the residual magnetism (206);
the magnetic field reversible permanent magnet producing acting force with the permanent magnet at one end of the solenoid under the action of the preset residual magnetism to couple the tool bit on the permanent magnet (207).

2. The magnetizing method according to claim 1, which is **characterized in that** before applying the preset magnetizing voltage to the solenoid of the preset turn number, it includes:

    setting the ampere turns of the solenoid (201);
    obtaining the peak magnetizing current of the solenoid according to the ampere turns of the solenoid and the corresponding relation between the turn number and the magnetizing current (202);
    obtaining the preset magnetizing voltage according to the peak magnetizing current and the DC resistance of the solenoid (203).

3. The magnetizing method according to one of the claims 1 to 2, which is **characterized in that**
the preset magnetizing voltage is more than or equal to 3 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid.

4. The magnetizing method according to claim 3, which is **characterized in that**
the preset magnetizing voltage is more than or equal to 5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid.

5. The magnetizing method according to one of the claims 1 to 2, which is **characterized in that** the preset turn number of the solenoid is 533, the DC resistance of the solenoid is 6.3Ω, and the peak magnetizing current of the solenoid is 1.65A;
the preset magnetizing voltage is 30.5V

6. The magnetizing method according to one of the claims 1 to 2, which is **characterized in that** the preset turn number of the solenoid is 533, the DC resistance of the solenoid is 6.3Ω, and the peak magnetizing current of the solenoid is 1.65A;
the preset magnetizing voltage is 61V.

7. A magnetizing apparatus, which is **characterized by**
a voltage supply module (31, 44) for applying a preset magnetizing voltage to a solenoid of a preset turn number, and the preset magnetizing voltage is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid;
a magnetizing module (32, 45) for magnetizing the magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid; a residual magnetism module (43) for calculating the preset residual magnetism of the magnetic field reversible permanent magnet when the magnetizing current of the solenoid is cut off, according to the ampere turns of the solenoid and the corresponding relation between the ampere turns and residual magnetism;
a couple module (47) for producing acting force with the permanent magnet at one end of the solenoid under the action of the preset residual magnetism of the magnetic field reversible permanent magnet thereby to couple the tool bit on the permanent magnet.

8. The magnetizing apparatus according to claim 7, which is **characterized in that** it also includes
a setting module (41) for setting the ampere turns of the solenoid;
a current module (42) for obtaining the peak magnetizing current of the solenoid according to the ampere turns of the solenoid and the corresponding relation between the turn number and the magnetizing current;
a voltage module (43) for calculating the preset magnetizing voltage according to the peak magnetizing current and the DC resistance of the solenoid.

**Patentansprüche**

1. Magnetisierungsverfahren **dadurch gekennzeichnet, dass**
eine vorbestimmte Magnetisierungsspannung an einer Magnetspule mit einer vorbestimmten Windungszahl angelegt wird, wobei die vorbestimmte Magnetisierungsspannung größer oder gleich dem 1,5-fachen des Produkts aus dem Gleichstromwiderstand der Magnetspule und der Magnetisierungsstromspitze der Magnetspule (S101) ist;
der Permanentmagnet mit reversiblem Magnetfeld in der Magnetspule bei der vorbestimmten Magnetisierungsspannung durch Anwenden der Magnetspule magnetisiert wird (S102); ein vorbestimmter Restmagnetismus des Permanentmagneten mit reversiblem Magnetfeld entsprechend der Amperewindungszahl der Magnetspule und dem entsprechenden Zusammenhang zwischen der Amperewindungszahl und dem Restmagnetismus (206) erreicht wird, wenn der Magnetisierungsstrom der Magnetspule abgeschaltet wird;
der Permanentmagnet mit reversiblem Magnetfeld eine Betätigungskraft mit dem Permanentmagnet an einem Ende der Magnetspule unter der Wirkung des vorbestimmten Restmagnetismus erzeugt, um das Werkzeug-Bit an den Permanentmagnet (207) zu koppeln.

2. Magnetisierungsverfahren gemäß Anspruch 1, **dadurch gekennzeichnet, dass** vor dem Anbringen der vorbestimmten Magnetisierungsspannung an die Magnetspule mit vorbestimmter Windungszahl:

die Amperewindungszahl der Magnetspule (201) eingestellt wird;
die Magnetisierungsstromspitze der Magnetspule gemäß der Amperewindungszahl der Magnetspule und dem entsprechenden Zusammenhang zwischen der Windungszahl und dem Magnetisierungsstrom (202) erreicht wird;
die vorbestimmte Magnetisierungsspannung gemäß der Magnetisierungsstromspitze und dem Gleichstromwi-

derstand der Magnetspule (203) erreicht wird.

3. Magnetisierungsverfahren nach einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet, dass** die vorbestimmte Magnetisierungsspannung größer oder gleich dem 3-fachen des Produkts aus dem Gleichstromwiderstand der Magnetspule und der Magnetisierungsstromspitze der Magnetspule ist.

4. Magnetisierungsverfahren gemäß Anspruch 3, **dadurch gekennzeichnet, dass** die vorbestimmte Magnetisiefungsspannung größer oder gleich dem 5-fachen des Produkts des Gleichstromwiderstands und der Magnetstromspitze der Magnetspule ist.

5. Magnetisierungsverfahren gemäß einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet, dass** die vorbestimmte Windungszahl der Magnetspule 533, der Gleichstromwiderstand der Magnetspule 6,3Ω und die Magnetisierungsstromspitze der Magnetspule 1,65A beträgt, wobei die vorbestimmte Magnetisierungsspannung 30,5V beträgt.

6. Magnetisierungsverfahren gemäß einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet, dass** die vorbestimmte Windungszahl der Magnetspule 533, der Gleichstromwiderstand der Spule 6,3 und die Magnetisierungsstromspitze der Magnetspule 1,65A beträgt, wobei die vorbestimmte Magnetisierungsspannung 61 V beträgt.

7. Magnetisierungsvorrichtung **gekennzeichnet durch**
ein Spannungsversorgungsmodul (31, 44) zum Anlegen einer vorbestimmten Magnetisierungsspannung an einer Magnetspule mit einer vorbestimmten Windungszahl, wobei die vorbestimmte Magnetisierungsspannung größer oder gleich dem 1,5-fachen des Produkts aus dem Gleichstromwiderstand der Magnetspule und der Magnetisierungsstromspitze der Magnetspule ist;
ein Magnetisierungsmodul (32, 45) zum Magnetisieren des Permanentmagneten mit reversiblem Magnetfeld in der Magnetspule bei der vorbestimmten Magnetisierungsspannung durch Anwenden der Magnetspule;
ein Restmagnetismusmodul (43) zum Berechnen des vorbestimmten Restmagnetismus des Permanentmagneten mit reversiblem Magnetfeld gemäß der Amperewindungszahl der Magnetspule und dem entsprechenden Zusammenhang zwischen der Amperewindungszahl und dem Restmagnetismus, wenn der Magnetisierungsstrom der Magnetspule abgeschaltet ist;
ein Koppelmodul (47) zum Erzeugen einer Betätigungskraft mit dem Permanentmagnet an einem Ende der Magnetspule unter der Wirkung des vorbestimmten Restmagnetismus des Permanentmagneten mit reversiblem Magnetfeld, wodurch das Werkzeug-Bit an den Permanentmagnet gekoppelt ist.

8. Magnetisierungsvorrichtung gemäß Anspruch 7, ferner **gekennzeichnet durch**
ein Einstellmodul (41) zum Einstellen der Amperewindungszahl der Magnetspule;
ein Strommodul (42) zum Erreichen der Magnetisierungsstromspitze der Magnetspule gemäß der Amperewindungszahl der Magnetspule und dem entsprechenden Zusammenhang zwischen der Amperewindungszahl und der Magnetisierungsspannung;
ein Spannungsmodul (43) zum Berechnen der vorbestimmten Magnetisierungsspannung gemäß der Magnetisierungsstromspitze und dem Gleichstromwiderstand der Magnetspule.

**Revendications**

1. Procédé de magnétisation, lequel est **caractérisé par**
l'application d'une tension de magnétisation préréglée à un solénoïde d'un nombre de tours préréglé, la tension de magnétisation préréglée étant supérieure ou égale à 1,5 fois le produit de la résistance CC du solénoïde et du courant de magnétisation de crête du solénoïde (S101);
la magnétisation de l'aimant permanent par champ magnétique réversible dans le solénoïde à la tension de magnétisation préréglée en adoptant le solénoïde (S 102) ;
l'obtention d'un magnétisme résiduel préréglé de l'aimant permanent par champ magnétique réversible lorsque le courant de magnétisation du solénoïde est coupé en fonction des ampèretours du solénoïde et du rapport correspondant entre les ampèretours et le magnétisme résiduel (206) ;
l'aimant permanent par champ magnétique réversible produisant une force d'actionnement avec l'aimant permanent à une extrémité du solénoïde sous l'action du magnétisme résiduel préréglé afin de coupler l'embout d'outil sur l'aimant permanent (207).

2. Procédé de magnétisation selon la revendication 1, lequel se **caractérise en ce que**, avant l'application de la tension

de magnétisation préréglée au solénoïde du nombre de tours préréglé, il comprend :

le réglage des ampèretours du solénoïde (201) ;
l'obtention du courant de magnétisation de crête du solénoïde en fonction des ampèretours du solénoïde et du rapport correspondant entre le nombre de tours et le courant de magnétisation (202) ;
l'obtention de la tension de magnétisation préréglée en fonction du courant de magnétisation de crête et de la résistance CC du solénoïde (203).

**3.** Procédé de magnétisation selon l'une des revendications 1 à 2, lequel est **caractérisé en ce que** la tension de magnétisation préréglée est supérieure ou égale à 3 fois le produit de la résistance CC du solénoïde et du courant de magnétisation de crête du solénoïde.

**4.** Procédé de magnétisation selon la revendication 3, lequel est **caractérisé en ce que** la tension de magnétisation préréglée est supérieure ou égale à 5 fois le produit de la résistance CC du solénoïde et du courant de magnétisation de crête du solénoïde.

**5.** Procédé de magnétisation selon l'une des revendications 1 à 2, lequel est **caractérisé en ce que** le nombre préréglé de tours du solénoïde est de 533, la résistance CC du solénoïde étant de 6,3Ω, et le courant de magnétisation de crête du solénoïde étant de 1,65A ;
la tension de magnétisation préréglée étant de 30,5V.

**6.** Procédé de magnétisation selon l'une des revendications 1 à 2, lequel est **caractérisé en ce que** le nombre préréglé de tours du solénoïde est de 533, la résistance CC du solénoïde étant de 6,3Ω, et le courant de magnétisation de crête du solénoïde étant de 1,65A ;
la tension de magnétisation préréglée étant de 61V.

**7.** Appareil de magnétisation, lequel est **caractérisé par**
un module l'alimentation en tension (31, 44) pour appliquer une tension de magnétisation préréglée à un solénoïde d'un nombre de tours préréglé, et la tension de magnétisation préréglée étant supérieure ou égale à 1,5 fois le produit de la résistance CC du solénoïde et du courant de magnétisation de crête du solénoïde ;
un module de magnétisation (32, 45) pour magnétiser l'aimant permanent par champ magnétique réversible dans le solénoïde à la tension de magnétisation préréglée en adoptant le solénoïde ; un module de magnétisme résiduel (43) pour calculer le magnétisme résiduel préréglé de l'aimant permanent par champ magnétique réversible lorsque le courant de magnétisation du solénoïde est coupé, en fonction des ampèretours du solénoïde et du rapport correspondant entre les ampèretours et le magnétisme résiduel ;
un module de couplage (47) pour produire une force d'actionnement avec l'aimant permanent à une extrémité du solénoïde sous l'action du magnétisme résiduel préréglé de l'aimant permanent par champ magnétique réversible afin de coupler de la sorte l'embout d'outil sur l'aimant permanent.

**8.** Appareil de magnétisation selon la revendication 7, lequel se **caractérisé en ce qu'**il comprend également
un module de réglage (41) pour régler les ampèretours du solénoïde ;
un module de courant (42) pour obtenir le courant de magnétisation de crête du solénoïde en fonction des ampèretours du solénoïde et du rapport correspondant entre le nombre de tours et le courant de magnétisation ;
un module de tension (43) pour calculer la tension de magnétisation préréglée en fonction du courant de magnétisation de crête et de la résistance CC du solénoïde.

| | |
|---|---|
| S101 | Apply a preset magnetizing voltage to a solenoid of a preset turn number, the preset magnetizing voltage is more than or equal to 1.5 times of the product of the DC resistance of the solenoid and the peak magnetizing current of the solenoid |
| ↓ | |
| S102 | magnetize the magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid |

Fig. 1

| | |
|---|---|
| 201 | Set the ampere turns of the solenoid |
| ↓ | |
| 202 | obtain the peak magnetizing current of the solenoid according to the ampere turns of the solenoid, and the corresponding relation between the turn number and the magnetizing current |
| ↓ | |
| 203 | obtain the preset magnetizing voltage according to the peak magnetizing current and the DC resistance of the solenoid |
| ↓ | |
| 204 | Apply a preset magnetizing voltage to the solenoid of a preset turn number |
| ↓ | |
| 205 | magnetize the magnetic field reversible permanent magnet in the solenoid at the preset magnetizing voltage by adopting the solenoid |
| ↓ | |
| 206 | obtain the preset residual magnetism kept by the magnetic field reversible permanent magnet when the magnetizing current of the solenoid is cut off, according to the ampere turns of the solenoid and the corresponding relation between the ampere turns and the residual magnetism |
| ↓ | |
| 207 | produces acting force with the permanent magnet at one end of the solenoid under the action of the preset residual magnetism of the magnetic field reversible permanent magnet to couple the tool bit on the permanent magnet. |

Fig. 2

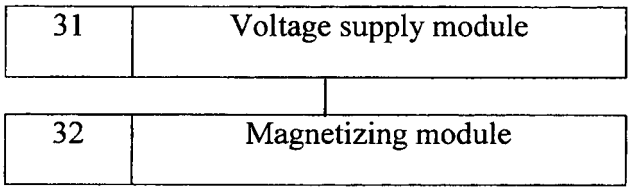
31
Voltage supply module
32
Magnetizing module

Fig. 3

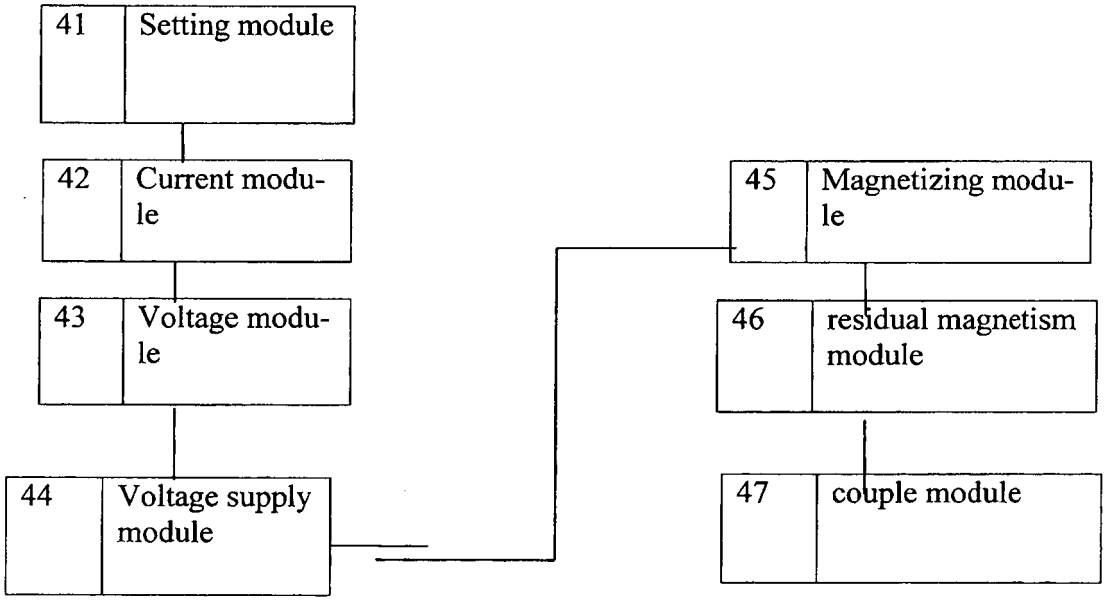
41
Setting module
42
Current module
43
Voltage module
44
Voltage supply module
45
Magnetizing module
46
residual magnetism module
47
couple module

Fig. 4

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- WO 2012089217 A2 **[0003]**