United States Patent Application Publication	20250256382
Kind Code	A1
Publication Date	August 14, 2025
Inventor(s)	Li; Guang et al.

NAIL GUN AND CONTROL METHOD THEREOF

Abstract

A nail gun includes a housing; an electric motor disposed in the housing; a battery pack configured to power the electric motor; a firing assembly configured to be capable of moving from an initial position to a firing position to drive a nail into a workpiece and moving from the firing position to the initial position within a nailing cycle; a parameter detection unit connected to at least the electric motor and configured to detect at least a working parameter of the electric motor; and a controller connected to at least the parameter detection unit. The controller is configured to, if the working parameter of the electric motor in a startup process is less than or equal to a parameter threshold, restrict a maximum duty cycle of a startup control signal to being less than or equal to a duty cycle threshold.

Inventors: **Li; Guang (Nanjing, CN), Yu; Xiaobo (Nanjing, CN), Wu; Yongkang (Nanjing, CN), Min; Yuemei (Nanjing, CN), Liu; Longxiang (Nanjing, CN), Xu; Tianxiao (Nanjing, CN), Du; Qi (Nanjing, CN), Sun; Guangcheng (Nanjing, CN)**

Applicant: **Nanjing Chervon Industry Co., Ltd.** (Nanjing, CN)

Family ID: **1000008604636**

Appl. No.: **19/191413**

Filed: **April 28, 2025**

Foreign Application Priority Data

CN	202311107865.3	Aug. 30, 2023
CN	202311107885.0	Aug. 30, 2023
CN	202311109669.X	Aug. 30, 2023
CN	202311110798.0	Aug. 30, 2023
CN	202311111812.9	Aug. 30, 2023
CN	202311113106.8	Aug. 30, 2023
CN	202311114950.2	Aug. 30, 2023
CN	202311224063.0	Sep. 21, 2023
CN	202311225795.1	Sep. 21, 2023

CN 202311226824.6 Sep. 21, 2023

Related U.S. Application Data

parent WO continuation PCT/CN2024/107478 20240725 PENDING child US 19191413

Publication Classification

Int. Cl.: **B25C1/06** (20060101); **B25C1/00** (20060101)

U.S. Cl.:

CPC **B25C1/06** (20130101); **B25C1/008** (20130101);

Background/Summary

RELATED APPLICATION INFORMATION [0001] This application is a continuation of International Application Number PCT/CN2024/107478, filed on Jul. 25, 2024, through which this application also claims the benefit under 35 U.S.C. § 119(a) of Chinese Patent Application No. 202311113106.8, filed on Aug. 30, 2023, Chinese Patent Application No. 202311109669.X, filed on Aug. 30, 2023, Chinese Patent Application No. 202311110798.0, filed on Aug. 30, 2023, Chinese Patent Application No. 202311107865.3, filed on Aug. 30, 2023, Chinese Patent Application No. 202311114950.2, filed on Aug. 30, 2023, Chinese Patent Application No. 202311111812.9, filed on Aug. 30, 2023, Chinese Patent Application No. 202311107885.0, filed on Aug. 30, 2023, and Chinese Patent Application No. 202311224063.0, filed on Sep. 21, 2023, Chinese Patent Application No. 202311225795.1, filed on Sep. 21, 2023, and Chinese Patent Application No. 202311226824.6, filed on Sep. 21, 2023, which applications are incorporated herein by reference in their entireties.

TECHNICAL FIELD
[0002] The present application relates to the technical field of power tools, for example, a nail gun.
BACKGROUND
[0003] Some power tools require a relatively high startup acceleration to start up, the duty cycle of a startup control signal increases to a target value in a short time, and a relatively large startup current appears in the startup process. If the power tools start up with a locked rotor or a heavy load, even if the duty cycle increases to the maximum, an electric motor may still fail to start, and overcurrent protection may not be performed and fail to respond to an instantaneous high current in time so that the machine may be burnt. The safety of startup control is particularly important for power tools that need to start and stop frequently, such as nail guns.
[0004] This part provides background information related to the present application, and the background information is not necessarily the existing art.
SUMMARY
[0005] A nail gun includes a housing; an electric motor disposed in the housing; a battery pack configured to power the electric motor; a firing assembly configured to be capable of moving from an initial position to a firing position to drive a nail into a workpiece and moving from the firing position to the initial position within a nailing cycle; a parameter detection unit connected to at least the electric motor and configured to detect at least a working parameter of the electric motor; and a controller connected to at least the parameter detection unit. The controller is configured to, if the working parameter of the electric motor in a startup process is less than or equal to a parameter

threshold, restrict a maximum duty cycle of a startup control signal to being less than or equal to a duty cycle threshold.

[0006] In some examples, the controller is configured to set the duty cycle threshold according to at least a battery parameter of the battery pack.

[0007] In some examples, the working parameter of the electric motor includes at least one of a rotational speed, number of revolutions, startup current, and startup voltage of the electric motor.

[0008] In some examples, the battery parameter of the battery pack includes at least one of electric power, a voltage, a temperature, a cell, and the number of parallel cells.

[0009] In some examples, the duty cycle threshold is inversely correlated to at least one battery parameter.

[0010] In some examples, the parameter threshold includes a minimum rotational speed of the electric motor during startup with a locked rotor.

[0011] In some examples, the parameter threshold includes a minimum number of revolutions of the electric motor during startup with a locked rotor.

[0012] In some examples, the parameter threshold includes a minimum rotational speed of the electric motor during startup with a heavy load.

[0013] In some examples, the parameter threshold includes a minimum number of revolutions of the electric motor during startup with a heavy load.

[0014] A power tool includes a housing; an electric motor disposed in the housing; a battery pack configured to power the electric motor; a parameter detection unit connected to at least the electric motor and configured to detect at least a working parameter of the electric motor; and a controller connected to at least the parameter detection unit. The controller is configured to, if the working parameter of the electric motor in a startup process is less than or equal to a parameter threshold, restrict a maximum duty cycle of a startup control signal to being less than or equal to a duty cycle threshold.

[0015] In some examples, the controller is configured to set the duty cycle threshold according to at least a battery parameter of the battery pack.

[0016] In some examples, the working parameter of the electric motor includes at least one of a rotational speed, number of revolutions, startup current, and startup voltage of the electric motor.

[0017] In some examples, the battery parameter of the battery pack includes at least one of electric power, a voltage, a temperature, a cell, and the number of parallel cells.

[0018] In some examples, the duty cycle threshold is inversely correlated to at least one battery parameter.

[0019] In some examples, the parameter threshold includes a minimum rotational speed of the electric motor during startup with a locked rotor.

[0020] In some examples, the parameter threshold includes a minimum number of revolutions of the electric motor during startup with a locked rotor.

[0021] A control method of a nail gun is provided. The nail gun includes a housing; an electric motor disposed in the housing; a battery pack configured to power the electric motor; a firing assembly configured to be capable of moving from an initial position to a firing position to drive a nail into a workpiece and moving from the firing position to the initial position within a nailing cycle; a parameter detection unit connected to at least the electric motor and configured to detect at least a working parameter of the electric motor; and a controller connected to at least the parameter detection unit. The control method includes: if the working parameter of the electric motor in a startup process is less than or equal to a parameter threshold, restricting a maximum duty cycle of a startup control signal to being less than or equal to a duty cycle threshold.

[0022] In some examples, the method further includes: setting the duty cycle threshold according to at least a battery parameter of the battery pack.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] To illustrate technical solutions in examples of the present application more clearly, the drawings used in the description of the examples are briefly described below. Apparently, the drawings described below illustrate only part of examples of the present application, and those of ordinary skill in the art may obtain other drawings based on the drawings described below on the premise that no creative work is done.

[0024] FIG. **1** is a perspective view of a nail gun.

[0025] FIG. **2** is a sectional view of the nail gun of FIG. **1**.

[0026] FIG. **3** is a schematic view of internal structures of the nail gun of FIG. **1** at an initial position.

[0027] FIG. **4** is a schematic view of internal structures of the nail gun of FIG. **1** at a firing position.

[0028] FIG. **5** is a perspective view of a drive wheel of the nail gun of FIG. **1**.

[0029] FIG. **6** is another perspective view of a nail gun.

[0030] FIG. **7** is a circuit schematic of a nail gun according to an example.

[0031] FIG. **8** is a flowchart of a control method of a nail gun according to an example.

[0032] FIG. **9** is a flowchart of a control method of a nail gun according to an example.

[0033] FIG. **10** is a schematic view of movement positions of a striker and numbers of revolutions of an electric motor in a nail gun according to an example.

[0034] FIG. **11** is a flowchart of a control method of a nail gun according to an example.

[0035] FIG. **12** is a flowchart of a control method of a nail gun according to an example.

[0036] FIG. **13** is a graph showing a relationship between temperature and minimum nailing time interval of a nail gun according to an example.

[0037] FIG. **14** is a graph showing a relationship between temperature and minimum nailing time interval of a nail gun according to an example.

[0038] FIG. **15** is a flowchart of a control method of a nail gun according to an example.

[0039] FIG. **16** is a schematic view showing one state of a backstop structure according to an example.

[0040] FIG. **17** is a schematic view showing the other state of a backstop structure according to an example.

[0041] FIG. **18** is a control circuit diagram of a light-emitting device according to an example.

[0042] FIG. **19** is a schematic showing display of a light-emitting device according to an example.

[0043] FIG. **20** is a circuit schematic of a nail gun according to an example.

[0044] FIG. **21** is a circuit schematic of a nail gun according to an example.

[0045] FIG. **22** is a flowchart of a control method of a nail gun according to an example.

DETAILED DESCRIPTION

[0046] Before any examples of this application are explained in detail, it is to be understood that this application is not limited to its application to the structural details and the arrangement of components set forth in the following description or illustrated in the above drawings.

[0047] In this application, the terms “comprising”, “including”, “having” or any other variation thereof are intended to cover an inclusive inclusion such that a process, method, article or device comprising a series of elements includes not only those series of elements, but also other elements not expressly listed, or elements inherent in the process, method, article, or device. Without further limitations, an element defined by the phrase “comprising a . . . ” does not preclude the presence of additional identical elements in the process, method, article, or device comprising that element.

[0048] In this application, the term “and/or” is a kind of association relationship describing the relationship between associated objects, which means that there can be three kinds of relationships.

For example, A and/or B can indicate that A exists alone, A and B exist simultaneously, and B exists alone. In addition, the character "/" in this application generally indicates that the contextual associated objects belong to an "and/or" relationship.

[0049] In this application, the terms "connection", "combination", "coupling" and "installation" may be direct connection, combination, coupling or installation, and may also be indirect connection, combination, coupling or installation. Among them, for example, direct connection means that two members or assemblies are connected together without intermediaries, and indirect connection means that two members or assemblies are respectively connected with at least one intermediate members and the two members or assemblies are connected by the at least one intermediate members. In addition, "connection" and "coupling" are not limited to physical or mechanical connections or couplings, and may include electrical connections or couplings.

[0050] In this application, it is to be understood by those skilled in the art that a relative term (such as "about", "approximately", and "substantially") used in conjunction with quantity or condition includes a stated value and has a meaning dictated by the context. For example, the relative term includes at least a degree of error associated with the measurement of a particular value, a tolerance caused by manufacturing, assembly, and use associated with the particular value, and the like. Such relative term should also be considered as disclosing the range defined by the absolute values of the two endpoints. The relative term may refer to plus or minus of a certain percentage (such as 1%, 5%, 10%, or more) of an indicated value. A value that did not use the relative term should also be disclosed as a particular value with a tolerance. In addition, "substantially" when expressing a relative angular position relationship (for example, substantially parallel, substantially perpendicular), may refer to adding or subtracting a certain degree (such as 1 degree, 5 degrees, 10 degrees or more) to the indicated angle.

[0051] In this application, those skilled in the art will understand that a function performed by an assembly may be performed by one assembly, multiple assemblies, one member, or multiple members. Likewise, a function performed by a member may be performed by one member, an assembly, or a combination of members.

[0052] In this application, the terms "up", "down", "left", "right", "front", and "rear" and other directional words are described based on the orientation or positional relationship shown in the drawings, and should not be understood as limitations to the examples of this application. In addition, in this context, it also needs to be understood that when it is mentioned that an element is connected "above" or "under" another element, it can not only be directly connected "above" or "under" the other element, but can also be indirectly connected "above" or "under" the other element through an intermediate element. It should also be understood that orientation words such as upper side, lower side, left side, right side, front side, and rear side do not only represent perfect orientations, but can also be understood as lateral orientations. For example, lower side may include directly below, bottom left, bottom right, front bottom, and rear bottom.

[0053] In this application, the terms "controller", "processor", "central processor", "CPU" and "MCU" are interchangeable. Where a unit "controller", "processor", "central processing", "CPU", or "MCU" is used to perform a specific function, the specific function may be implemented by a single aforementioned unit or a plurality of the aforementioned unit.

[0054] In this application, the term "device", "module" or "unit" may be implemented in the form of hardware or software to achieve specific functions.

[0055] In this application, the terms "computing", "judging", "controlling", "determining", "recognizing" and the like refer to the operations and processes of a computer system or similar electronic computing device (e.g., controller, processor, etc.).

[0056] As for the definitions of up, down, left, right, front, and rear in the present application, reference may be made to the orientations shown in FIGS. **1** to **4**.

[0057] As shown in FIGS. **1** and **2**, a nail gun **100** includes a housing **11**, a power output portion **12**, a cylinder **13**, and a magazine assembly **14**. The housing **11** includes a first accommodation space **111** extending along a direction of a first straight line **101** and a second accommodation space **112** extending along a direction of a second straight line **102**. In an example, the power output portion **12** may be partially disposed in the first accommodation space **111** or partially disposed in the second accommodation space **112**. In an example, the power output portion **12** may include an electric motor **121** or an energy storage device. The energy storage device may be understood as one that releases stored kinetic energy during the first half of a nailing cycle to achieve nailing and stores energy during the second half of the nailing cycle to prepare for the next nailing. The energy storage device may be a cylinder capable of pre-storing gas, a cylinder capable of inflation and deflation during working, or an elastic element such as a spring. In this example, a cylinder **13** serves as the energy storage device and is disposed in the second accommodation space **112**.

[0058] The housing **11** is further formed with a handle portion **113** for a user to hold. A power interface **1131** is provided at an end of the handle portion **113** and configured to connect a direct current or alternating current power supply. In this example, the power interface **1131** is configured to connect a battery pack **15**. A main switch **113***a* is provided on the handle portion **113** and used for the user to control the start and stop of the nail gun **100**.

[0059] The other end of the handle portion **113** is connected to the cylinder **13**, and the cylinder **13** extends along the direction of the second straight line **102**, where the first straight line **101** and the second straight line **102** are perpendicular to each other. The magazine assembly **14** is disposed along a direction of a third straight line **103** parallel to the first straight line **101**. As an optional example, the magazine assembly **14** is provided with a window **141** for the user to observe the remaining nails. The window **141** is configured to be one or more gaps on the magazine assembly **14**. In one aspect, the window **141** may be used for the user to check the number of the remaining nails. In the other aspect, the window **141** may be used for the user to perform simple maintenance on the magazine assembly **14** without detaching the magazine assembly **14**.

[0060] A firing assembly **16** is disposed in the cylinder **13**, and gas in the cylinder **13** does work to push the firing assembly **16** to move, thereby driving a nail. The nail gun **100** further includes a striking portion **17**. The striking portion **17** is at least partially disposed in the cylinder **13** and may be, for example, a piston disposed in the cylinder **13** and connected to the firing assembly **16**. The striking portion **17** may be connected to the firing assembly **16** and can strike the firing assembly **16** so that the firing assembly **16** moves within the cylinder **13**. In an example, the cylinder **13** further includes an inflation nozzle configured to pre-fill gas into the cylinder **13**. The pre-filled gas in a compressed state stores a relatively large amount of kinetic energy and can push the striking portion **17** to quickly strike the firing assembly **16** so that the firing assembly **16** drives the nail. Alternatively, the cylinder **13** may include an air intake nozzle and an air exhaust nozzle so that the cylinder **13** does not need to be pre-filled with gas and may be inflated in a working process of the nail gun **100**.

[0061] The cylinder **13** that can be pre-filled with gas is used as an example here. After the nail gun **100** shuts down, the electric motor **121** stops outputting power and can make the firing assembly **16** stop at the initial position. The pre-filled gas in the cylinder **13** is in the compressed state. After the nail gun **100** is powered on and the electric motor is started, the electric motor **121** outputs power, the firing assembly **16** is released, and the striking portion **17** can convert the kinetic energy of the cylinder **13** into a striking force for striking the firing assembly **16** so that the firing assembly **16** obtains instantaneously a relatively large acceleration, moves to a firing position shown in FIG. **4**, and drives the nail. After the nail is driven out, the firing assembly **16** is driven by the electric motor **121** to return from the firing position shown in FIG. **4** to an initial position shown in FIG. **3** and shuts down, during which the firing assembly **16** can continuously drive the striking portion **17** to compress the gas in the cylinder **13**. A process from the startup of the nail gun to when the firing assembly **16** returns to the initial position or the proximity of the initial position, that is, a shutdown position after nailing is referred to as a nailing cycle. It is to be noted that the initial position shown in FIG. **3** is a position at which the firing assembly **16** stops after the nail gun **100** shuts down and may also be referred to as the shutdown position. A position to which the firing assembly **16** can move upward farthest may be referred to as a top dead point, and a position to which the firing assembly **16** can move downward farthest is referred to as a bottom dead point. The firing position and the bottom dead point may be the same position, while the initial position approaches the top dead point from bottom to top but is not the top dead point, that is to say, the distance between the initial position and the top dead point is greater than 0.

[0062] As shown in FIG. **2**, the electric motor **121** extends basically along the direction of the first straight line **101**, and the cylinder **13** and the firing assembly **16** disposed in the cylinder **13** extend basically along the direction of the second straight line **102**. The electric motor **121** and the cylinder **13** are basically perpendicular to each other. The electric motor **121** drives the firing assembly **16** to move within the cylinder **13**. In an optional implementation, the electric motor **121** may be part of the electric motor **121**. The electric motor **121** can output power to a drive shaft **124**, and a drive wheel **125** is disposed on the drive shaft **124**. The firing assembly **16** includes at least a striker **161**. In an example, the firing assembly **16** may further include the striking portion **17**, where the striking portion **17** may be a piston connected to the top of the striker **161**. The piston is fixedly or detachably connected to the striker **161**. The striking portion **17** can compress the pre-filled gas in the cylinder **13** in the process of the striker **161** being driven to move upward, that is, towards the initial position. The striker **161** is formed with transmission teeth **161***a*, and the striker **161** can move along the direction of the second straight line **102** within the cylinder **13**, where the second straight line **102** may be understood as a nailing direction. The drive wheel **125** can mate with the transmission teeth **161***a* to drive the firing assembly **16** to do work against pressure in the cylinder **13** so that the firing assembly **16** can move to the initial position shown in FIG. **3**.

[0063] As shown in FIGS. **4** and **5**, the drive wheel **125** is a gear structure. The drive wheel **125** is formed with a second connecting hole **125***a* for the drive shaft **124** to be connected to. The second connecting hole **125***a* is specifically a flat hole. When the drive shaft **124** is connected to the second connecting hole **125***a*, the drive wheel **125** can rotate synchronously with the drive shaft **124**. Multiple drive teeth **125***g* are formed around a body portion of the drive wheel **125**, and the drive teeth **125***g* include a first tooth **125***b* at a starting end and a second tooth **125***d* at a tail end. Here, a drive tooth **125***g* that first contacts the striker **161** of the firing assembly **16** when the drive wheel **125** starts driving the firing assembly **16** to reset to the initial position shown in FIG. **3** is defined as the first tooth **125***b*, and a drive tooth **125***g* that last meshes with the striker **161** of the firing assembly **16** when the firing assembly **16** is already at the initial position is defined as the second tooth **125***d*. A first section **125***e* and a second section **125***f* are included between the first tooth **125***b* and the second tooth **125***d*. The multiple drive teeth **125***g* are evenly distributed on the first section **125***e*; and the second section **125***f* is smooth and continuous without any drive teeth **125***g*. When the drive teeth **125***g* on the first section **125***e* mesh with the transmission teeth **161***a* on the striker **161**, the drive wheel **125** can drive the striker **161** to compress the gas in the cylinder **13** and do work. When the second section **125***f* mates with the striker **161**, since the second section **125***f* is smooth and continuous, the striker **161** is not stopped by the drive teeth **125***g* and is rapidly pushed out by the gas in the cylinder **13**, achieving the nailing effect.

[0064] In other examples, the drive wheel **125** may be another form of drive component, and the structures and forms of other possible drive wheels **125** are not specifically limited in the present application.

[0065] In this example, the nail gun **100** is provided with a light-emitting device **18**. The light-emitting device **18** may be one or more light-emitting diode (LED) lamp beads arranged at different positions, a light strip, a Nixie tube, or a display screen. As shown in FIG. **6**, the light-emitting device **18** includes three LED lamps disposed on the housing **11**. One light-emitting device **181** is disposed directly above a horizontal plane where the striker **161** is located, and the other two light-emitting devices **182** can collaborate with the light-emitting device **181** to project a V-shaped, arrow-shaped, or triangular light spot on a workpiece to be nailed, where the light spot can indicate a nailing position on the workpiece. In an implementation, the other two light-emitting devices **182** are disposed on the left and right sides of the front end of the housing **11** of the nail gun **100**.

[0066] As is known, after the nail gun is used for a long time, the cylinder **13** may experience air leakage due to a material or sealing issue. If the cylinder **13** leaks, the pre-filled gas in the cylinder **13** is reduced, or insufficient inflation may occur in a working process of the cylinder **13**. Thus, the compressed gas has reduced kinetic energy, and the nailing strength or depth of the nail gun is affected. Moreover, when the electric motor **121** outputs the same power to drive the firing assembly **16** to return to the initial position, that is, the shutdown position, due to the reduced gas in the cylinder **13**, the firing assembly **16** may fail to shut down when reaching the initial position, causing a safety hazard. Similarly, after the nail gun with the energy storage device being the elastic element such as the spring is used for a long time, an elastic force of the spring may degrade, and the spring has reduced kinetic energy, that is, elastic energy after being compressed, which also affects the nailing strength or depth or causes a safety hazard.

[0067] To solve the preceding problem, it is necessary to accurately detect whether the cylinder leaks or whether the elastic force of the spring degrades and to issue a timely alarm for maintenance after it is determined that the cylinder leaks or the elastic force degrades.

[0068] As shown in FIG. **7**, a control circuit **200** of the nail gun may include at least a parameter detection unit **21**, a driver circuit **22**, a controller **23**, the light-emitting device **18**, and the electric motor **121**. As a power supply for the control circuit **200**, the battery pack **15** can not only provide electrical energy for driving the electric motor **121** but also provide electrical energy at a low voltage for the controller **23** after conversion by a power conversion unit, provide electrical energy for the parameter detection unit **21**, or provide electrical energy for the light-emitting device **18**. This example illustrates only a power supply path for the battery pack **15** to provide electrical energy for the electric motor **121** and omits a detailed description of other possible power supply paths.

[0069] In an example, the driver circuit **22** is connected between the controller **23** and the electric motor **121** and may receive control signals output from the controller **23** and change its own conduction state, so as to control an operating state of the electric motor **121**, including, for example, shutdown, rotation, a rotational speed, or a direction of rotation. Optionally, the driver circuit **22** may consist of one or more power elements. In an example, as shown in FIG. **7**, the driver circuit **22** includes multiple power elements VT**1**, VT**2**, VT**3**, VT**4**, VT**5**, and VT**6**. Each gate terminal of the power elements is electrically connected to the controller **23** and configured to receive a control signal from the controller **23**. Each drain or source of the power elements is connected to a stator winding of the electric motor **121**. The power elements VT**1** to VT**6** receive the control signals from the controller **23** to change their respective on states, thereby changing a current loaded to stator windings of the electric motor **121** by the battery pack. In an example, the driver circuit **22** may be a three-phase bridge driver circuit including six controllable semiconductor power devices (such as field-effect transistors (FETs), bipolar junction transistors (BJTs), or insulated-gate bipolar transistors (IGBTs)). It is to be understood that the preceding power elements may be any other types of solid-state switches, such as the IGBTs or the BJTs.

[0070] To make the electric motor **121** rotate, the driver circuit **22** has multiple driving states. In one driving state, the stator windings of the electric motor generate a magnetic field, and the controller **23** outputs corresponding pulse-width modulation (PWM) control signals to switching elements in the driver circuit according to a rotor position or a back electromotive force of the electric motor so that the driving state of the driver circuit is switched and thus the stator windings generate a changing magnetic field to drive a rotor to rotate, thereby achieving the rotation or commutation of the electric motor. It is to be noted that any other circuits and control manners that can drive the rotation or commutation of the electric motor can be applied to the present disclosure and the circuit structure of the driver circuit **22** and the control of the driver circuit **22** by the controller **23** are not limited in the present disclosure.

[0071] The parameter detection unit **21** can detect at least a working parameter of the electric motor **121** or an electrical parameter of the battery pack **15**. In an example, the parameter detection unit **21** may detect an output current, an output voltage, or output power of the electric motor **121**, a working time of the electric motor **121** within the nailing cycle (that is, a time of the nailing cycle), a nailing frequency, the number of revolutions of the electric motor within the nailing cycle, or the like. In an example, the parameter detection unit **21** may also detect a battery parameter of the battery pack **15**, such as an output voltage, a current, energy consumption, or power consumption of the battery pack within the nailing cycle. It is to be understood that the parameter detection unit **21** may include one or more detection devices that can detect various different working parameters or battery parameters separately or simultaneously.

[0072] In this example, if the cylinder **13** has no air leakage or the elastic force of the spring does not degrade, output energy of the electric motor **121** in every nailing cycle is basically the same, or the energy consumption of the battery pack **15** in every nailing cycle is also basically the same. If the cylinder **13** leaks or the elastic force of the spring degrades, the energy required for the electric motor **121** to drive the firing assembly **16** to drive the striking portion **17** to gradually compress the gas or the spring in any nailing cycle is reduced, and the energy consumption of the battery pack **15** is also reduced. That is to say, the output energy of the electric motor **121** and/or the energy consumption of the battery pack **15** within at least one nailing cycle is analyzed so that a sum or integral of the energy of the electric motor or the energy of the battery pack over a time period can be formed, the problem of relatively low reliability in comparing energy or currents or voltages or power at discrete moments can be avoided, and whether the cylinder **13** leaks or whether the elastic force of the spring degrades can be more accurately determined.

[0073] In this example, the controller **23** can acquire at least the working parameter of the electric motor **121** and/or the electrical parameter of the battery pack **15** and may determine a magnitude of the output energy of the electric motor **121** within at least one nailing cycle or the energy consumption of the battery pack **15** within at least one nailing cycle according to the acquired parameters. For example, the controller **23** may calculate the output energy of the electric motor within the nailing cycle according to a product of the output current and output voltage of the electric motor **121** within the nailing cycle and the time of the nailing cycle.

[0074] It is to be noted that the pressure in the cylinder **13** changes within the nailing cycle as the firing assembly **16** moves within the cylinder **13**, but average pressure in the cylinder **13** within the nailing cycle may be considered basically unchanged. If the cylinder **13** leaks, the pressure in the cylinder decreases, that is, the pressure at any moment or the average pressure within the nailing cycle decreases, and then the output energy of the electric motor **121** within the nailing cycle decreases or the energy consumption of the battery pack **15** within the nailing cycle decreases. That is to say, the output energy of the electric motor **121** within the nailing cycle or the energy consumption of the battery pack **15** within the nailing cycle is positively correlated to the pressure in the cylinder **15** or positively correlated to at least the average pressure of the cylinder **13** within the nailing cycle. In an example, the positive correlation may be linear or nonlinear. According to this relationship, the controller **23** may determine the pressure in the cylinder **13** or determine at least a magnitude of the average pressure in the cylinder **13** within the nailing cycle according to the currently calculated output energy of the electric motor **121** and/or energy consumption of the battery pack **15** within at least one nailing cycle. Similarly, when the energy storage device is the spring, the output energy of the electric motor **121** within the nailing cycle or the energy consumption of the battery pack **15** within the nailing cycle is positively correlated to the elastic force of the spring or positively correlated to at least the average elastic force of the spring within the nailing cycle. In an example, the positive correlation may be linear or nonlinear. According to this relationship, the controller **23** may determine the elastic force of the spring or determine at least a magnitude of the elastic force of the spring within the nailing cycle according to the currently calculated output energy of the electric motor **121** and/or energy consumption of the battery pack **15** within at least one nailing cycle. In this example, the pressure in the cylinder **13** or the elastic force of the spring may be understood as the kinetic energy of the energy storage device or may at least correspond to the kinetic energy of the energy storage device.

[0075] It is assumed that when the cylinder **13** has no air leakage, the output energy of the electric motor **121** within the nailing cycle is W**11** or the energy consumption of the battery pack **15** within the nailing cycle is W**21**, and the average pressure in the cylinder **13** is Pa**1**. After the cylinder **13** leaks, the output energy of the electric motor **121** within the nailing cycle is W**12** or the energy consumption of the battery pack **15** within the nailing cycle is W**22**, and the average pressure in the cylinder **13** is Pa**2**, where W**12** is less than W**11**, W**22** is less than W**21**, and Pa**2** is less than Pa**1**.

[0076] In an example, the controller **23** may set the average pressure Pa**1** within the nailing cycle when the cylinder **13** has no air leakage as a pressure threshold. When the pressure in the cylinder **13** is determined to be less than the pressure threshold according to the output energy of the electric motor **121** within the nailing cycle and/or the energy consumption of the battery pack **15** within the nailing cycle, it may be determined that the cylinder **13** leaks, and the controller **23** may control the electric motor **121** to stop working, for example, control the electric motor **121** to be powered off or stop outputting the control signals.

[0077] In an example, the controller **23** may also control the light-emitting device **18** to display different prompt information when determining a relationship between the pressure in the cylinder **13** and the pressure threshold. For example, when the pressure is lower than the pressure threshold, the cylinder **13** may have the air leakage problem, and the controller **23** may control the light-emitting device **18** to output prompt information in a first manner, where the first manner may include at least one of the number of light-emitting devices, an emitted color, a light emission frequency, a brightness level, or the content displayed through light emission. When the pressure is basically equal to the pressure threshold, the controller **23** may control the light-emitting device **18** to emit no light or to emit light in a second manner different from the first manner. When the pressure is greater than the pressure threshold, the controller **23** may control the light-emitting device **18** to emit light in a light emission manner different from the first manner and the second manner.

[0078] Similarly, for the determination of the elastic force of the spring or a warning manner for the elastic force of the spring, reference may be made to the determination of the pressure in the cylinder **13** or the warning manner for the pressure in the cylinder **13**, and the details are not repeated here.

[0079] As shown in FIG. **8**, a control flow of the nail gun may include at least the steps below.

[0080] In S**101**, the working parameter of the electric motor within at least one nailing cycle is acquired.

[0081] In S**102**, the pressure in the cylinder is determined according to the working parameter within the at least one nailing cycle.

[0082] In S**103**, when the pressure is lower than the pressure threshold, the electric motor is controlled to stop working.

[0083] As shown in FIG. **9**, a control flow of the nail gun may include at least the steps below.

[0084] In S**201**, the working parameter of the electric motor and/or the electrical parameter of the battery pack within at least one nailing cycle are acquired.

[0085] In S**202**, the pressure in the cylinder is determined according to the working parameter and/or the electrical parameter within the at least one nailing cycle.

[0086] In S**203**, the relationship between the pressure in the cylinder and the pressure threshold is determined.

[0087] In S**204**, when the pressure in the cylinder is lower than the pressure threshold, the light-emitting device is controlled to output the prompt information in the first manner.

[0088] In S**205**, when the pressure in the cylinder is basically equal to the pressure threshold, the light-emitting device is controlled to output the prompt information in the second manner.

[0089] In S**206**, when the pressure in the cylinder is greater than the pressure threshold, the light-emitting device is controlled to output the prompt information in a third manner.

[0090] As is known, at the end of the nailing cycle of the nail gun, the striker **161** stops at the shutdown position. Generally, the controller **23** may determine whether to shut down according to a working time of the electric motor **121** after power-on. For example, if the nailing cycle is T, the controller **23** may control the electric motor to shut down after the electric motor **121** has rotated for a time T**1**. However, if a rotational speed of the electric motor is too high, when the electric motor is shut down at a preset shutdown moment, the electric motor may fail to stop rotating completely when the striker **161** has already reached the shutdown position, and thus the striker **161** may be driven to continue moving to the initial position or even perform double strikes.

[0091] Since a correspondence between the number of revolutions of the electric motor **121** and a position of the striker **161** is not affected by the rotational speed of the electric motor or other factors, to accurately control the shutdown position of the striker **161**, the shutdown position of the striker **161** may be controlled according to the number of revolutions of the electric motor **121** in the present application. In an example, referring to the control circuit shown in FIG. **7**, the parameter detection unit **21** may also detect the number of revolutions of the electric motor **121**. For example, the parameter detection unit **21** may start counting from 0 after the electric motor is started and calculate the number of revolutions of the electric motor according to the number of commutations of the electric motor. The controller **23** may determine, according to the number of revolutions of the electric motor, a timing to control the electric motor to operate at a constant speed, so as to ensure that the electric motor is operating at a constant rotational speed before the electric motor stops rotating and ensure the accuracy of control of the shutdown position.

[0092] Referring to FIG. **10**, the relationship between the position of the striker **161** and the number of revolutions of the electric motor within the nailing cycle is illustrated by using any physical point of the striker **161** as a reference point. In FIG. **10**, the number 0 indicates that the number of revolutions of the electric motor is 0 when the electric motor is just powered on and the striker **161** is at the initial position or the shutdown position, N**1** represents the number of revolutions of the electric motor **121** when the electric motor **121** drives the striker **161** to move from the initial position to the firing position, and N**2** represents the number of revolutions of the electric motor **121** when the electric motor **121** is powered on and drives the striker **161** to return to the shutdown position after nailing. N**3** represents the number of revolutions of the electric motor **121** when a shutdown signal is triggered in the process of the striker **161** returning from the firing position to the initial position. It is to be understood that a Hall sensor may be disposed on the drive wheel **125** to detect the position of the striker **161**, and the shutdown signal is triggered when the striker **161** moves to a preset position. In response to the shutdown signal, the controller **23** may control the electric motor **121** to stop rotating.

[0093] In this example, when the number of revolutions of the electric motor **121** is greater than or equal to a first revolution number threshold and less than a second revolution number threshold, the controller **23** may control the electric motor **121** to operate at the constant speed. The first revolution number threshold may be the number of revolutions N**1** in FIG. **10**, and the second revolution number threshold may be the number of revolutions N**3** in FIG. **10**. That is to say, before detecting the shutdown signal, the controller **23** may control, in advance, the electric motor **121** to operate at the constant speed, so as to ensure that the rotational speed is stable when the electric motor brakes. A stable or constant initial brake speed can ensure that the number of revolutions of the electric motor **121** from the start of braking to the stop of rotation is stable, thereby ensuring that the striker **161** can stably stop at the shutdown position.

[0094] In other examples, before detecting the shutdown signal, the controller **23** may control, in other manners, the electric motor **121** to operate at the constant speed until the shutdown signal is detected so that the electric motor can have the stable initial brake speed, ensuring that the striker

161 can stably stop at the shutdown position.

[0095] In an example, the controller **23** may control the constant speed of operation of the electric motor **121** according to the energy stored in the energy storage device. Generally, the greater the energy stored in the energy storage device, the higher the constant rotational speed of operation of the electric motor, and vice versa. That is to say, the energy currently stored in the energy storage device is positively correlated to the constant rotational speed of operation of the electric motor.

[0096] In this example, the energy storage device is configured to be the cylinder **13**. When the number of revolutions of the electric motor **121** is greater than or equal to the first revolution number threshold and less than the second revolution number threshold, the controller **23** may acquire the magnitude of the pressure in the cylinder **13** and set the constant rotational speed of operation of the electric motor according to the magnitude of the pressure, or the controller **23** may calculate the kinetic energy of the cylinder **13** according to the pressure in the cylinder **13** and set the constant speed of operation of the electric motor according to the kinetic energy. In an implementation, the kinetic energy of the cylinder **13** may be kinetic energy at the current moment or average kinetic energy of the cylinder **13** within the nailing cycle. In an implementation, the controller **23** may calculate the pressure in the cylinder **13** in the manner described in the preceding example: the pressure in the cylinder **13** is determined according to the output energy of the electric motor **121** within at least one nailing cycle and/or the energy consumption of the battery pack **15** within at least one nailing cycle. The details are not repeated here.

[0097] As shown in FIG. **11**, a control flow of the nail gun may include at least the steps below.

[0098] In S**301**, the number of revolutions of the electric motor is acquired.

[0099] In S**302**, when the number of revolutions is greater than or equal to the first revolution number threshold and less than the second revolution number threshold, the electric motor is controlled to operate at the constant speed.

[0100] In S**303**, when a brake signal is detected, the electric motor brakes with the initial brake speed being the constant rotational speed.

[0101] Some power tools require a relatively high startup acceleration to start up, such as the nail gun, a reciprocating saw, and a jigsaw. To quickly start the power tools, a duty cycle of a startup signal needs to be increased to a target value, for example, to the maximum in a short time. However, during the quick startup of the power tools, a relatively large startup current appears. If the power tools start up with a locked rotor or a heavy load, the tools may be burnt. Especially for power tools that need to start and stop frequently, such as the nail gun, an ability to start safely and quickly is an important performance indicator to ensure the normal working of the nail gun.

[0102] To avoid the preceding problem, this example provides a control method for startup of a power tool, with the nail gun as an example.

[0103] Still referring to the control circuit of the nail gun shown in FIG. **7**, the parameter detection unit **21** may detect the working parameter of the electric motor **121** and detect at least the working parameter of the electric motor **121** in the startup process. For example, the parameter detection unit **21** may detect one or more of the rotational speed, the number of revolutions, a startup current, or a startup voltage of the electric motor **121**. The controller **23** may set a maximum duty cycle of a control signal for controlling the startup of the electric motor **121** according to the acquired working parameter of the electric motor **121**. In this example, a maximum duty cycle of a startup control signal of the electric motor is adjusted according to the working parameter of the electric motor so that when the power tool is forcibly started due to the locked rotor or the heavy load in the startup process, the tool can be prevented from being damaged. The startup process can be understood as a process of the electric motor accelerating from a stationary state to an expected speed after receiving a starting signal.

[0104] In the startup process of the electric motor **121**, when the controller **23** detects that the working parameter of the electric motor **121** is less than or equal to a parameter threshold, it may be considered that the electric motor **121** may start up with the heavy load or the locked rotor, and consequently, the maximum duty cycle of the startup control signal may be configured to be less than or equal to a duty cycle threshold. It is to be understood that in different types of power tools, different parameter thresholds may be set for the working parameter of the electric motor. For example, the parameter threshold may be a minimum rotational speed or a minimum number of revolutions of the electric motor **121** during startup with the locked rotor or may be a minimum rotational speed or a minimum number of revolutions of the electric motor during startup with the heavy load.

[0105] In an example, the controller **23** may set the duty cycle threshold according to the battery parameter of the battery pack **15**. For example, the duty cycle threshold may be set according to at least one of battery power, a voltage, a temperature, a cell, and the number of parallel cells of the battery pack. In this example, the duty cycle threshold is inversely correlated to at least one battery parameter. For example, the lower the voltage of the battery pack **15**, the greater the duty cycle threshold. For example, the nail gun **100** is generally powered by a 24 V battery pack. If the controller **23** detects that the voltage of the battery pack **15** is lower than 24 V, the duty cycle threshold for the startup control signal is set to 100% so that when the working parameter of the electric motor **121** is less than or equal to the parameter threshold, the duty cycle of the startup control signal can be increased to a maximum of 100%. If the controller **23** detects that the voltage of the battery pack **15** is higher than 24 V, the duty cycle threshold for the startup control signal is set to be lower than 100%, for example, to 60% so that when the working parameter of the electric motor **121** is less than or equal to the parameter threshold, the duty cycle of the startup control signal can be increased to a maximum of 60%. This ensures that when the power tool is mounted with battery packs with different voltages or battery power, the startup performance of the power tool remains basically consistent so that an ability of the machine to resist the locked rotor can be enhanced.

[0106] As shown in FIG. **12**, a control flow of the nail gun may include at least the steps below.

[0107] In S**401**, the working parameter of the electric motor is monitored in the startup process of the electric motor.

[0108] In S**402**, if the working parameter of the electric motor is less than or equal to the parameter threshold, the maximum duty cycle of the startup control signal is restricted to being less than or equal to the duty cycle threshold.

[0109] In S**403**, the battery parameter of the battery pack is acquired.

[0110] In S**404**, the duty cycle threshold is set according to the battery parameter.

[0111] The order of some or all flow steps in a flowchart of the present application is not limited to the steps defined in the flowchart, where steps may be performed in parallel or may be interchanged. For example, steps S**403** and S**404** may be performed in parallel with or interchanged with step S**401**.

[0112] The nail gun **100** generally works in an environment that requires continual and constant nailing. After working for a long time, the temperature of a component such as the cylinder **13** or the electric motor **121** rises excessively, for example, the temperature of the electric motor **121** may reach 150° C. If the nail gun **100** still performs constant and rapid nailing at such a high temperature, some parts inside the nail gun are very likely to be damaged, for example, a circuit board may be burnt or the electric motor is short-circuited. Therefore, the present application provides a nail gun that can detect the temperature and control a startup frequency or startup time interval of the nail gun.

[0113] Still referring to the control circuit of the nail gun **100** shown in FIG. **7**, the parameter detection unit **21** may include a temperature detection unit capable of detecting temperature data, which can detect the temperature of at least one position in the nail gun **100**. In this example, the temperature detection unit may include one or more temperature sensors, such as a thermistor sensor, a thermocouple sensor, a temperature sensor, a platinum resistance temperature sensor, and a digital output sensor.

[0114] In an example, the temperature detection unit can detect the temperature of the electric motor **121**, such as the temperature of a stator or rotor of the electric motor. Alternatively, the temperature detection unit can detect the temperature of a circuit board where the control circuit is located or the temperature of a power element on the circuit board, the temperature in the cylinder **13** or the temperature of a cylinder wall or the temperature of the striking portion **17**, the temperature of the striker **161**, the temperature of the piston, or the temperature at an air outlet on the housing **11** of the nail gun **100**. The air outlet here may be a heat dissipation opening close to the electric motor **121** or a heat dissipation opening close to the circuit board. In other examples, the temperature detection unit may detect the temperatures of any other positions in the nail gun **100**, which are not listed one by one here. The temperature in this example may be understood as the temperature of at least one position or element in the nail gun **100**.

[0115] In this example, the controller **23** may acquire the temperature detected by the temperature detection unit and adjust a minimum nailing time interval of the nail gun **100** according to a relationship between the temperature and a set temperature threshold. It is to be noted that a time interval between the end of a nailing cycle and the start of the next nailing cycle of the nail gun **100** may be referred to as a nailing time interval, and the minimum nailing time interval may be understood as a minimum time interval between two adjacent nailing cycles. In this example, a starting moment of the nailing cycle may be a time when the controller **23** detects the startup signal, and an ending moment of the nailing cycle may be a time when the controller **23** detects the shutdown signal. Therefore, the nailing time interval may be a time period from when the controller **23** detects the shutdown signal in the former nailing cycle to when the controller **23** detects the startup signal at the beginning of the latter nailing cycle.

[0116] Since the nailing frequency may be understood as the number of nailing times in a unit time, the nailing time interval and the nailing frequency are interchangeable in some examples. For example, the controller **23** may adjust the nailing frequency of the nail gun **100** according to the temperature of the nail gun **100**.

[0117] In an example, when the temperature of at least one position in the nail gun **100** is less than or equal to the temperature threshold, the controller **23** may set the minimum nailing time interval to T**1**. When the temperature is greater than the temperature threshold, the controller **23** may set the minimum nailing time interval to T**2**, where T**2** is greater than T**1**. Alternatively, when the temperature of at least one position in the nail gun **100** is less than or equal to the temperature threshold, the controller **23** may set a maximum nailing frequency to f**1**. When the temperature is greater than the temperature threshold, the controller **23** may set the maximum nailing frequency to f**2**, where f**2** is less than f**1**. It is to be understood that after the temperature of the nail gun **100** exceeds a predetermined value, the minimum nailing time interval of the nail gun **100** increases, or the nailing frequency of the nail gun decreases. For example, when the temperature of the nail gun is less than or equal to 100° C., the minimum nailing time interval is 1 s, which may be understood as that in the case where the temperature of the nail gun **100** is less than or equal to 100° C., the nailing time interval between any two adjacent nailing cycles is greater than or equal to is. When the temperature of the nail gun is greater than 100° C., the minimum nailing time interval is 2 s, which may be understood as that in the case where the temperature of the nail gun **100** is greater than 100° C., the nailing time interval between any two adjacent nailing cycles is greater than or equal to 2 s.

[0118] In an example, the temperature of the nail gun **100** is positively correlated to the minimum nailing time interval. For example, as the temperature of the nail gun rises continuously, the minimum nailing time interval set by the controller **23** increases. In an example, as shown in FIG. **13**, the temperature of the nail gun and the minimum nailing time interval have a linear relationship, where the horizontal axis represents the temperature t of the nail gun, and the vertical axis represents the minimum nailing time interval TI. When the temperature of the nail gun is less than a temperature threshold t**0**, the minimum nailing time interval TI of the nail gun may be a constant value. When the temperature of the nail gun is greater than or equal to the temperature threshold, the higher the temperature t, the greater the minimum nailing time interval TI, which basically have the linear relationship. In an example, as shown in FIG. **14**, the temperature of the nail gun and the minimum nailing time interval have a step-like relationship. That is to say, any temperatures within a certain temperature interval correspond to the same minimum nailing time interval. In other examples, the temperature of the nail gun and the minimum nailing time interval may have other relationships. It is to be understood that the temperature of the nail gun may be inversely correlated to the maximum nailing frequency. That is, as the temperature of the nail gun rises continuously, the maximum nailing frequency set by the controller **23** decreases.

[0119] In an example, if the controller **23** detects the startup signal and determines that a time between the startup signal and the shutdown signal received last time is less than the minimum nailing time interval, the startup signal may be ignored, that is, the electric motor **121** is not controlled to start, the electric motor **121** is controlled not to start, the electric motor **121** is controlled not to be powered on, or no drive signal is output to drive the electric motor **121**. If the controller **23** detects the startup signal and determines that the time between the startup signal and the shutdown signal received last time is greater than or equal to the minimum nailing time interval, the electric motor **121** is controlled to start.

[0120] In this example, when the temperature of the nail gun exceeds a certain value, the minimum nailing time interval is prolonged or the nailing frequency is reduced so that the nail gun can have a certain time to cool down or lower the temperature, avoiding continuous working at a high temperature within a short time, improving the safety of the nail gun, and ensuring the working performance of the nail gun.

[0121] As shown in FIG. **15**, a control flow of the nail gun may include at least the steps below.

[0122] In S**501**, the temperature of the nail gun is acquired.

[0123] In S**502**, when the temperature of the nail gun is less than or equal to the temperature threshold, the minimum nailing time interval of the nail gun is set to T**1**.

[0124] In S**503**, when the temperature of the nail gun is greater than the temperature threshold, the minimum nailing time interval is set to T**2**.

[0125] In an example, to prevent the striker **161** from slipping down in the process of the striker **161** moving from the firing position to the initial position or after the nail gun **100** shuts down, a backstop structure **19** may be used for stopping or locking the striker, as shown in FIGS. **16** and **17**.

[0126] Still referring to FIGS. **16** and **17**, the backstop structure **19** may include a solenoid **191**, an elastic element **192**, a push rod **193**, and a stop portion **194**. The solenoid **191** can be electrically connected to at least the controller **23**, and the controller **23** can control the solenoid **191** to be energized or de-energized. As shown in FIG. **16**, when the solenoid **191** is in a de-energized state, the elastic element **192** is in an extended state, and the stop portion **194** connected to the push rod **193** is engaged with a backstop tooth **162** on the other side of the striker **161**, enabling the striker **161** to remain at the initial position and not slip down. After the nail gun is started and the electric motor **121** is powered on, the solenoid **191** is energized, generates an electromagnetic effect, and attracts the push rod **193** to compress along a first direction **1** so that the stop portion **194** can rotate clockwise and be disengaged from the backstop tooth **162**. Without being stopped, the striker **161** can be driven by the power in the cylinder **13** to drive the nail.

[0127] That is to say, the energized solenoid **191** can make the stop portion **194** in a failure state, that is, the stop portion **194** cannot lock the striker **161** or is not in contact with the striker **161** so that the striker **161** can be driven by the drive wheel **125** to move from the initial position to the firing position to drive the nail. When the solenoid **191** is de-energized, the stop portion **194** is in a stop state, that is, the stop portion **194** can lock the striker **161** at the initial position or at least prevent the striker **161** from slipping down in the process of the striker **161** moving from the firing position to the initial position.

[0128] If the solenoid **191** cannot be activated in time to make the stop portion **194** in the stop state when the striker **161** moves to the initial position after nailing, the striker **161** may slip accidentally, resulting in continual strikes or other safety accidents.

[0129] To solve the preceding problem, still referring to the control circuit diagram of the nail gun shown in FIG. **7**, the parameter detection unit **21** can detect the number of revolutions of the electric motor **121**. When the electric motor **121** is started, the controller **23** controls the solenoid **191** to be energized so that the stop portion **194** works in the failure state, and the striker **161** can move from the initial position to the firing position. After the electric motor **121** is powered on, the controller **23** may continuously monitor the number of revolutions of the electric motor **121** and controls the solenoid **191** to be de-energized when the number of revolutions is greater than or equal to a revolution number threshold so that the stop portion **194** works in the stop state and can prevent the striker **161** from slipping during its upward movement to return to the initial position and can lock the striker **161** at the initial position. That is to say, after the nail gun **100** shuts down, the solenoid **191** remains in the de-energized state. Even if the nail gun **100** is not in operation for a long time, the backstop structure **19** does not need to keep the solenoid **191** in an energized state to lock the striker **161** so that the solenoid can be prevented from working for a long time and having a relatively high temperature. The revolution number threshold in this example may be the number of revolutions of the electric motor **121** when the striker **161** reaches the firing position after the electric motor **121** is started. Since a displacement of the striker **161** is determined when the electric motor **121** rotates a certain number of revolutions, the solenoid is controlled to be de-energized according to the number of revolutions of the electric motor, ensuring that the striker can be locked by the solenoid and the solenoid can be prevented from being energized for a long time and generating heat.

[0130] It is to be understood that in the process of the striker **161** moving downward from the initial position to the firing position, the striker **161** relies on the power stored in the energy storage device, that is, the cylinder **13**, to rapidly complete nailing. In this process, the drive wheel **125** does not mesh with the striker **161**, and the electric motor **121** drives the drive wheel **125** to rotate. However, in the process of the striker **161** moving upward from the firing position after nailing, the drive wheel **125** meshes with the striker **161**, the striker **161** moves upward under the drive of the drive wheel **125**, and the electric motor **121** changes from not driving the striker **161** to driving the striker **161**. A working state of electric motor **121** changes and therefore the working parameter of the electric motor **121** has a relatively large change. For example, when the striker **161** starts to move upward from the firing position, a working current or output torque or the rotational speed of the electric motor **121** changes to a relatively large degree, where an output current of the electric motor increases, the output torque of the electric motor increases, or the rotational speed of the electric motor decreases.

[0131] In this example, the controller **23** may also monitor at least one of the output current, output torque, or rotational speed of the electric motor to determine whether the striker **161** starts to move upward from the firing position. For example, when monitoring that the output current of the electric motor or a rate of change of the output current is greater than a set threshold, the controller **23** may control the solenoid **191** to be de-energized so that the stop portion **194** works in the stop state. Alternatively, when detecting that the output torque of the electric motor or a rate of change of the torque is greater than a set threshold, the controller **23** may control the solenoid **191** to be de-energized so that the stop portion **194** works in the stop state. Alternatively, when detecting that the rotational speed or acceleration of the electric motor is greater than a set threshold, the controller **23** may control the solenoid **191** to be de-energized so that the stop portion **194** works in the stop state.

[0132] Referring to a control circuit of the light-emitting device shown in FIG. **18**, some units or devices are consistent with those in FIG. **7** and use the same reference numerals as those in FIG. **7**. The parameter detection unit **21** may include a sensor that can detect a total number of nails in the magazine assembly **14** or the number of the remaining nails, a sensor that can detect the depth of the driven nail, or a sensor that can detect the nailing strength. Types, mounting positions, or working manners of various sensors are not specifically limited in this example.

[0133] The controller **23** may acquire information transmitted by the parameter detection unit **21** and control the light-emitting device **18** to display first information about the nails in the magazine assembly **14** and/or second information about the driven nail. In an example, the first information may include the specific number of the remaining nails in the magazine assembly **14**, a number range of the remaining nails, or alarm information when the number of the remaining nails is less than a preset number. The second information may include the nailing depth, the nailing strength, or a nailing angle of the driven nail or a nailing interval between driven nails.

[0134] In this example, the light-emitting device **18** shown in FIGS. **1** and **6** includes LED Nixie tubes **181** and **182** or at least one light strip composed of multiple LEDs and may also include a display screen **183** shown in FIG. **6**. The Nixie tube may display the first information and/or the second information in one or more manners such as a light intensity, a flashing frequency, the number of flashes, the emitted color, and the number of lights. The display screen **183** may directly display content data. For example, as shown in FIG. **19**, the light-emitting device **18** may display a graphic of the nail and the number of nails or the number of the remaining nails, display an image or the depth of the nail driven actually, or display a nailing animation. The light-emitting device is not limited to the Nixie tube or the display screen, and any light-emitting device that can display the preceding information is within the scope of the present application.

[0135] In an example, the controller **23** may also display fault information or a current working mode of the nail gun **100** or information about the battery pack. The fault information may include various common faults, such as overtemperature, overvoltage, undervoltage, overcurrent, the locked rotor, and anti-lock. The working mode may include a single strike mode (that is, a single drive mode) and a continual strike mode (that is, a continual drive mode). Battery information may include the remaining battery power, remaining battery time, output voltage, output current, or temperature of the battery pack. In this example, the light-emitting device **18** may also display the fault information, the working mode, or the information about the battery pack in at least one manner of the light intensity, the flashing frequency, the number of flashes, the emitted color, the light emission number, or content data display.

[0136] In an example, the light-emitting device **18** may display different fault codes to represent different fault information, for example, E**1** represents overtemperature of a power tube in the control circuit, E**2** represents the locked rotor of the electric motor, and E**3** represents battery undervoltage. Faults are displayed through different fault codes so that different fault types of the nail gun are not affected by the number of light-emitting devices **18**, the emitted color, or the light emission frequency, and more intelligent and simpler fault display is implemented.

[0137] In an example, the display screen **183**, as the light-emitting device, may include an operation interface, which may be, for example, a touch interface or an interface that can be combined with physical buttons. The operation interface can receive operation information from the user and may transmit the operation information to the controller **23** while displaying the operation information. The controller **23** may control, according to an operation of the user, the electric motor **121** to work. For example, the user may select a nailing mode, switch the nailing mode, or set an operating parameter of the nail gun on the operation interface, for example, set the nailing strength, nailing depth, nailing time interval, or nailing frequency.

[0138] In an example, the light-emitting device **18** may be divided into a lighting device and a fault prompt device. In some examples, the lighting device and the fault prompt device may be the same device or different devices. If the lighting device and the fault prompt device are the same light-emitting device, when the nail gun **100** has no fault, the light-emitting device **18** remains in an always on state. When the nail gun **100** has a fault, the fault may be prompted in a manner such as the flashing frequency, the color, the number of flashes, or a fault code, or the light-emitting device may be off to prompt the fault. If the lighting device and the fault prompt device are different light-emitting devices, when the nail gun **100** has no fault, the lighting device may remain in the always on state, and the fault prompt device may remain in an always off state. When the fault occurs, the lighting device may remain always on or be off, and the fault prompt device may prompt the fault in the preceding fault prompt manner. If the lighting device and the fault prompt device are different light-emitting devices, when the nail gun **100** has no fault, the lighting device and the fault prompt device may both remain in the always on state. When the fault occurs, the lighting device may remain always on or be off, and the fault prompt device may be off to prompt the fault or prompt the fault in the preceding fault prompt manner. In an example, when or after prompting a fault type, the fault prompt device may prompt a fault level through the emitted color and/or the flashing frequency. For example, in response to no fault, a green light is always on; in response to a minor fault (such as undervoltage protection or overtemperature protection), a yellow light is on or flashing; and in response to a serious fault (such as overcurrent protection, locked-rotor protection, or anti-lock protection), a red light is on or flashing.

[0139] In an example, the parameter detection unit **21** may be a brightness sensor or another sensor that can detect an illumination intensity of a working environment of the nail gun. The controller **23** may control, according to the detected illumination intensity, whether the light-emitting device **18** is turned on or control the light intensity. For example, during working outdoors in daytime with good weather, the light-emitting device **18** may be controlled to be off, or at least the lighting device may be controlled to be off. During working in a dim indoor environment, the brightness of the light-emitting device may be increased, or at least the brightness of the lighting device may be increased.

[0140] Referring to a control circuit of the nail gun shown in FIG. **20**, the control circuit includes some structures or parts the same as those in the control circuit in FIG. **7**, and the circuit in FIG. **20** uses the same reference numerals as that in FIG. **7**. The control circuit includes at least a first control circuit **24** capable of controlling the light-emitting device **18** and a second control circuit **25** for controlling the electric motor **121**. When the electric motor **121** is not powered on, the first control circuit **24** can at least independently control the light-emitting device **18** to be on. That is, in the case where the electric motor **121** is not started, the first control circuit **24** controls, in advance, the light-emitting device **18** to be on. When the light-emitting device **18** is turned on before nailing, the workpiece or the working environment can be illuminated in advance so that the user obtains better user experience. Even if the electric motor **121** fails to start, the lighting device **18** can work.

[0141] In an example, the first control circuit **24** and the second control circuit **25** may be disposed on the same circuit board. In an example, the first control circuit **24** and the second control circuit **25** may be disposed on different circuit boards.

[0142] Referring to a control circuit of the nail gun shown in FIG. **21**, the first control circuit **24** includes at least a light emission control switch **241** and a light emission circuit **242**. After being operated by the user, the light emission control switch **241** can conduct a current path between the light emission circuit **242** and the battery pack **15** so that the light-emitting device **18** can be turned on. In this example, the light emission control switch **241** may be a button switch, a toggle switch, a membrane switch, a lever switch, a microswitch, a travel switch, or the like. The second control circuit **25** is basically consistent with the control circuit in FIG. **7**, is a circuit for controlling the operation or shutdown of the electric motor **121**, and may also be referred to as a main control circuit of the nail gun **100**. In this example, the second control circuit **25** may include a body switch **251**, the driver circuit **22**, and the controller **23**. After being operated by the user, the body switch **251** can conduct a current path between the controller **23**, the driver circuit **22**, and the electric motor **121**. After outputting the control signals, the controller **23** can control the operation of the electric motor **121**. For implementations where the controller **23** controls the operation of the electric motor **121**, reference may be made to the description of the control circuit shown in FIG. **7**, and the details are not repeated here. It is to be noted that the body switch **251** may be the button switch, the toggle switch, the membrane switch, the lever switch, the microswitch, the travel switch, or the like.

[0143] In other examples, it may be considered that the light emission control switch **241** does not belong to the first control circuit **24** but is connected to the first control circuit **24**. Alternatively, it is considered that the body switch **251** does not belong to the second control circuit **25** but is connected to the second control circuit **25**. That is to say, the control circuit may be divided in other manners, which can be accepted as long as the corresponding functions can be implemented.

[0144] In an example, the nail gun **100** may include one travel switch (not shown). The travel switch functions as the light emission control switch **241** in response to a first switch travel and functions as the body switch **251** in response to a second switch travel. In an example, when the travel switch has the second switch travel, the controller **23** in the second control circuit **25** is conductive, while the electric motor **121** is not started. When the travel switch is operated to a third switch travel, the electric motor **121** is started. In an example, when the travel switch is operated to a fourth switch travel, the controller **23** may perform a particular control operation on the electric motor **121**, for example, the controller **23** can control the electric motor **121** to operate at the constant speed.

[0145] In an example, the light emission control switch **241** may be operated to control the light-emitting device **18** to be turned off. Alternatively, the controller **23** in the second control circuit **25** may control the light emission circuit **242** to be powered off to turn off the light-emitting device **18**. In an example, the controller **23** may control the light emission circuit **242** to be disconnected with a delay so that the light-emitting device **18** is turned off with a delay. It is to be understood that the function of the light emission circuit **242** may be implemented by different elements, and the specific circuit structure of the light emission circuit is not limited in the present application.

[0146] Still referring to FIG. **21**, the controller **23** may control, according to the working parameter of the electric motor **121** and/or the battery parameter of the battery pack **15** detected by the parameter detection unit **21**, the light emission circuit **242** to change a circuit state so that the light-emitting device **18** can a light emission form to issue an alarm prompt. The working parameter of the electric motor **121** may be the output current, output voltage, or output power of the electric motor **121**, the working time of the electric motor **121** within the nailing cycle (that is, the time of the nailing cycle), the nailing frequency, the number of revolutions of the electric motor within the nailing cycle, the temperature of the electric motor, or the like. The battery parameter may be the output voltage, current, energy consumption, or power consumption of the battery pack **15** within the nailing cycle, the temperature of the battery pack **15**, or the like. For example, when determining the locked rotor of the electric motor according to the current of the electric motor **121**, the controller **23** may control the electric motor **121** to stop rotating and control the light emission circuit **242** to change the circuit state so that the light-emitting device **18** flashes and/or emits red light as an alarm prompt. In this example, the controller **23** may control the light-emitting device **18** to issue the alarm prompt in at least one form of the number of light-emitting devices, the emitted color, the light emission frequency, the number of flashes, the brightness level, or the content displayed through light emission. The controller **23** may also set an alarm according to a fault type or a fault level.

[0147] Still referring to FIGS. **1** and **2**, the nail gun **100** includes a push rod switch **113***b* in addition to a trigger switch **113***a*. The trigger switch **113***a* is configured to control the start and stop of the nail gun **100**. The push rod switch **113***b* may serve as a safety switch and be disposed at the lower end of the firing assembly **16**. When the user pushes the nail gun **100** downward along the nailing direction, that is, the direction of the second straight line **102**, the push rod switch **113***b* can abut against the workpiece so that the push rod switch **113***b* is turned on, that is, the push rod switch **113***b* is triggered. In this example, the nail gun **100** is further provided with a guide assembly **114**, where the guide assembly **114** may be formed by the housing **11** or disposed on the housing **11** and can partially or fully cover the firing assembly **16** and at least guide the firing assembly **16** to perform nailing in the nailing direction. It is to be understood that the lower end of the guide assembly **114** may be an exit of the nail. A height difference exists between the lower end of the push rod switch **113***b* and the lower end of the guide assembly **114**. When the push rod switch **113***b* is just in contact with the workpiece, the distance between the lower end of the guide assembly **114** and the workpiece is the height difference.

[0148] Generally, the nail gun **100** can include at least two working modes: a single drive mode and a continual drive mode. In the single drive mode, one nail can be driven each time. In the continual drive mode, nails are driven continually multiple times. In an example, the trigger switch **113***a* and the push rod switch **113***b* are triggered in different manners corresponding to different working modes of the nail gun **100**. For example, in the case where the push rod switch **113***b* abuts against the workpiece, the trigger switch **113***a* is operated so that the single drive mode of the nail gun **100** can be enabled to drive one nail. When the trigger switch **113***a* is operated and the push rod switch **113***b* abuts against the workpiece, the continual drive mode of the nail gun **100** can be enabled. In the continual drive mode, the trigger switch **113***a* is continuously operated, and the user only needs to intermittently press the push rod switch **113***b* against the workpiece so that the nails can be driven continually. That is to say, in the case where the trigger switch **113***a* is always triggered by the user, one nail is driven every time the push rod switch **113***b* abuts against the workpiece. That is to say, continual nailing does not mean continuous nailing but that in the case where the trigger switch **113***a* is continuously triggered by the user, one nail is driven every time the push rod switch **113***b* is turned on. Generally, when a relatively heavy workload is required or when the workpiece has good continuity or planarity and needs to be fastened at multiple positions, the user may perform the continual nailing in the continual drive mode to improve the working efficiency.

[0149] However, some drawbacks exist in the continual drive mode. For example, to further improve the nailing efficiency, in the case where the trigger switch **113***a* is operated, the nail is driven when the push rod switch **113***b* abuts against the workpiece, that is, is triggered to turn on. Generally, when the push rod switch **113***b* abuts against the workpiece to be turned on, there is still a certain distance between the lower end of the guide assembly **114** and a surface of the workpiece, affecting the nailing quality and the nailing effect. For example, some driven nails are exposed out of the workpiece.

[0150] To solve this problem, in the continual drive mode, the controller **23** may at least control a nailing timing of the nail gun **100** according to the distance from the lower end of the guide assembly **114** to the surface of the workpiece. The nailing timing may be understood as an objective nailing moment. Alternatively, the controller **23** may control the nailing timing according to the distance between another relatively fixed position of the nail gun **100** and the surface of the workpiece. Still referring to FIG. **7**, the parameter detection unit **21** may detect the distance from the lower end of the guide assembly **114** to the surface of the workpiece. In this example, the parameter detection unit **21** may be a distance sensor, and the distance sensor may be disposed at the lower end (not shown) of the guide assembly **114** or at another fixed position of the nail gun **100**, which is not limited here. In some examples, the distance sensor may be a laser sensor, an ultrasonic sensor, an infrared sensor, or the like.

[0151] In the continual drive mode, when detecting that the distance from the lower end of the guide assembly **114** to the surface of the workpiece is less than or equal to a preset distance, the controller **23** may control the electric motor **121** to operate so that the firing assembly **16** can be released from the initial position to drive the nail. The preset distance may be any distance greater than or equal to 0. That is to say, nailing is triggered when the lower end of the guide assembly **114** is in contact with the surface of the workpiece or when the lower end of the guide assembly **114** is very close to the surface of the workpiece. The effect of the nailing when the nail is relatively far from the surface of the workpiece on the nailing quality and the nailing effect is avoided. When detecting that the distance from the lower end of the guide assembly **114** to the surface of the workpiece is greater than the preset distance, the controller **23** does not start at least the nailing until the detected distance is less than or equal to the preset distance. It may also be understood as that when the distance from the lower end of the guide assembly **114** to the surface of the workpiece is detected to be greater than the preset distance, a time it takes to start the nailing is extended.

[0152] In an example, not starting the nailing may include reducing a startup speed. For example, the electric motor **121** may be controlled to reduce the rotational speed to reduce a speed at which the nailing is started so that a relatively long time is obtained to operate the push rod switch **113***b* to continuously depress. Thus, the guide assembly **114** can be closer to the surface of the workpiece in the case where the user continuously depresses the push rod switch **113***b* so that the nail gun **100** can have a shorter nailing distance in the continual drive mode.

[0153] In an example, the control circuit of the nail gun **100** shown in FIG. **7** may include at least one filter element. For example, the power elements VT**1** to VT**6** in the driver circuit **22** may serve as filter elements, or a filter capacitor may be provided in the control circuit. A position of the filter element in the control circuit and a type of the filter element are not limited in this example, and any element with the filtering function in the control circuit is within the scope of the present application. In this example, not starting the nailing may include extending a filtering time of the filter element in the control circuit. For example, the filter element is controlled to perform filtering at least two times. The filtering time of the control circuit is extended so that a relatively long time can be obtained to operate the push rod switch **113***b* to continuously depress. Thus, the guide assembly **114** can be closer to the surface of the workpiece in the case where the user continuously depresses the push rod switch **113***b* so that the nail gun **100** can have the shorter nailing distance in the continual drive mode.

[0154] It is to be understood that the controller **23** may adopt other manners to extend the time it takes to start the nailing. That is to say, other solutions or concepts for reducing the distance from the guide assembly **114** to the surface of the workpiece by extending the time it takes to start the nailing in the continual drive mode to achieve the better nailing quality and effect are within the scope of the present application.

[0155] It is assumed that in the continual drive mode, a time from when the push rod switch **113***b* starts to abut against the surface of the workpiece to when the firing assembly **16** drives the nail is a nailing response time. In this example, the nailing response time is greater than or equal to a time from when the trigger switch **113***a* is operated to when the firing assembly **16** drives the nail in the single drive mode. Without a significant increase in the nailing response time, the better nailing effect and quality are achieved.

[0156] As shown in FIG. **22**, a control flow of the nail gun includes at least the steps below.

[0157] In S**601**, the control flow starts.

[0158] In S**602**, it is determined whether the nail gun is currently working in the continual drive mode. If so, step S**603** is performed; otherwise, the working mode of the nail gun continues to be monitored.

[0159] In S**603**, the distance between the lower end of the guide assembly and the surface of the workpiece is detected.

[0160] In S**604**, it is determined whether the distance is less than or equal to the preset distance.

[0161] If so, step S**605** is performed; otherwise, step S**606** is performed.

[0162] In S**605**, the electric motor is controlled to operate to start the nailing.

[0163] In S**606**, the nailing is not started.

[0164] The basic principles, main features, and advantages of the present application are shown and described above. It is to be understood by those skilled in the art that the preceding examples do not limit the present application in any form, and any technical solutions obtained through equivalent substitutions or equivalent transformations are within the scope of the present application.

Claims

1. A nail gun, comprising: a housing; an electric motor disposed in the housing; a battery pack configured to power the electric motor; a firing assembly configured to be capable of moving from an initial position to a firing position to drive a nail into a workpiece and moving from the firing position to the initial position within a nailing cycle; a parameter detection unit connected to the electric motor and configured to detect at least a working parameter of the electric motor; and a controller connected to at least the parameter detection unit and configured to, when the working parameter of the electric motor in a startup process is less than or equal to a parameter threshold, restrict a maximum duty cycle of a startup control signal to being less than or equal to a duty cycle threshold.
2. The nail gun of claim 1, wherein the controller is configured to set the duty cycle threshold according to at least a battery parameter of the battery pack.
3. The nail gun of claim 1, wherein the working parameter of the electric motor comprises at least one of a rotational speed, number of revolutions, startup current, and startup voltage of the electric motor.
4. The nail gun of claim 2, wherein the battery parameter of the battery pack comprises at least one of electric power, a voltage, a temperature, a cell, and a number of parallel cells.
5. The nail gun of claim 2, wherein the duty cycle threshold is inversely correlated to at least one battery parameter.
6. The nail gun of claim 1, wherein the parameter threshold comprises a minimum rotational speed of the electric motor during startup with a locked rotor.
7. The nail gun of claim 1, wherein the parameter threshold comprises a minimum number of revolutions of the electric motor during startup with a locked rotor.
8. The nail gun of claim 1, wherein the parameter threshold comprises a minimum rotational speed of the electric motor during startup with a heavy load.
9. The nail gun of claim 1, wherein the parameter threshold comprises a minimum number of revolutions of the electric motor during startup with a heavy load.
10. A power tool, comprising: a housing; an electric motor disposed in the housing; a battery pack configured to power the electric motor; a parameter detection unit connected to the electric motor and configured to detect at least a working parameter of the electric motor; and a controller connected to the parameter detection unit and configured to, when the working parameter of the electric motor in a startup process is less than or equal to a parameter threshold, restrict a maximum duty cycle of a startup control signal to being less than or equal to a duty cycle threshold.
11. The power tool of claim 10, wherein the controller is configured to set the duty cycle threshold according to at least a battery parameter of the battery pack.
12. The power tool of claim 10, wherein the working parameter of the electric motor comprises at least one of a rotational speed, number of revolutions, startup current, and startup voltage of the electric motor.
13. The power tool of claim 11, wherein the battery parameter of the battery pack comprises at least one of electric power, a voltage, a temperature, a cell, and a number of parallel cells.
14. The power tool of claim 11, wherein the duty cycle threshold is inversely correlated to at least one battery parameter.
15. The power tool of claim 11, wherein the parameter threshold comprises a minimum rotational speed of the electric motor during startup with a locked rotor.
16. The power tool of claim 11, wherein the parameter threshold comprises a minimum number of revolutions of the electric motor during startup with a locked rotor.
17. A control method of a nail gun, the nail gun comprising a housing; an electric motor disposed in the housing; a battery pack configured to power the electric motor; a firing assembly configured to

be capable of moving from an initial position to a firing position to drive a nail into a workpiece and moving from the firing position to the initial position within a nailing cycle; a parameter detection unit connected to at least the electric motor and configured to detect at least a working parameter of the electric motor; and a controller connected to at least the parameter detection unit; and the control method comprising: when the working parameter of the electric motor in a startup process is less than or equal to a parameter threshold, restricting a maximum duty cycle of a startup control signal to being less than or equal to a duty cycle threshold.

18. The control method of a nail gun of claim 17, further comprising: setting the duty cycle threshold according to at least a battery parameter of the battery pack.

19. The control method of a nail gun of claim 17, wherein the working parameter of the electric motor comprises at least one of a rotational speed, number of revolutions, startup current, and startup voltage of the electric motor.

20. The control method of a nail gun of claim 18, wherein the battery parameter of the battery pack comprises at least one of electric power, a voltage, a temperature, a cell, and a number of parallel cells.