with large load torque fluctuations at the time of startup of the motor drive device, and needs to balance between an inlet pressure and an outlet pressure of compressor 101 by using four-way valve 106 at the time of stoppage of compressor 101 to stably start up compressor 101. This leads to complexity and an increase in cost of the system.

Citation List

Patent Literature

PTL 1: Unexamined Japanese Patent Publication No. 10-028395

SUMMARY

The present disclosure has been made in consideration of the above conventional problems and provides a motor drive device that stably starts up even while load torque fluctuations are large.

According to an aspect, there is provided a motor drive device comprising:

a brushless DC motor (5) configured to drive a load, the brushless DC motor (5) including a permanent magnet and a stator (5b) having a three-phase winding;

a speed controller (8) configured to decide a pulse width modulation (PWM) ON ratio for performing PWM control on the brushless DC motor (5);

a PWM ON ratio increasing-reducing unit (9) configured to increase or reduce the PWM ON ratio in accordance with a driving speed of the brushless DC motor (5); and

a drive unit (10) configured to perform the PWM control to drive the brushless DC motor (5) in accordance with the PWM ON ratio decided by the PWM ON ratio increasing-reducing unit (9),

a position detector (6) configured to detect a rotational position of the

rotor (5a) based on a induced voltage generated in the three-phase winding of stator (5b); and

a speed detector (7) configured to calculate a current driving speed of the brushless DC motor (5) and an average speed of one past rotation from position information detected by the position detector (6), characterized in that

the PWM ON ratio increasing-reducing unit (9) sets the PWM ON ratio to a ratio equal to or lower than the PWM ON ratio decided by the speed controller (8) in an interval in which the driving speed of the brushless DC motor (5) is lower than a predetermined speed, and sets the PWM ON ratio to a ratio equal to or higher than the PWM ON ratio decided by the speed controller in an interval in which the driving speed is higher than the predetermined speed, , wherein the predetermined speed is the average speed of one past rotation.

More specifically, a motor drive device according to an example of an exemplary embodiment of the present disclosure includes a brushless DC motor that drives a load and a speed controller that decides a PWM ON ratio for performing PWM control on the brushless DC motor. In addition, the motor drive device includes a PWM ON ratio increasing-reducing unit that sets the PWM ON ratio equal to or lower than the PWM ON ratio decided by the speed controller in an interval in which a driving speed of the brushless DC motor is lower than a predetermined speed, and sets the PWM ON ratio equal to or higher than the PWM ON ratio decided by the speed controller in an interval in which the driving speed of the brushless DC motor is higher than the predetermined speed. Furthermore, the motor drive device includes a drive unit that performs PWM control for driving the brushless DC motor in accordance with the PWM ON ratio decided by the PWM ON ratio increasing-reducing unit.

With such configuration, the motor drive device increases output torque of the brushless DC motor in an interval in which a load becomes heavy, and reduces the output torque of the brushless DC motor in an interval in which the load becomes light. In an interval in which required torque is small and a speed is low, excessive output torque is suppressed, whereas in an interval in which the torque is insufficient and the speed is high, the output torque can be increased. This makes it possible to start up the motor drive device while reducing a change in speed and vibration even under a condition in which load torque fluctuations are large.

In addition, with regard to vibration at the time of startup of the motor drive device, it is possible to change an applied voltage in accordance with torque fluctuations and adjust a current flowing in the brushless DC motor. This can reduce vibrations at the time of startup of the motor drive device.

The above configuration can also reduce a peak current by reducing the PWM ON ratio to make it difficult for a current to flow in an interval in which the driving speed of the brushless DC motor decreases, which is an interval in which an induced voltage of the brushless DC motor decreases and a current easily flows. This makes it possible to achieve energy saving by the use of a high-efficiency motor with a small demagnetizing current and to achieve a reduction in cost by the use of an element with a small current rating.

A motor drive device according to an example of an exemplary embodiment of the present disclosure may be configured to drive a compressor in a refrigeration cycle in which the compressor, a condenser, a capillary, an evaporator, and the compressor are connected in the order named and to start up while a pressure difference is left between an inlet side and an outlet side of the compressor.

This configuration allows the motor drive device to start up even while

there is a pressure difference between the inlet side and the outlet side of the compressor, thereby reducing a loss in the refrigeration cycle without raising a temperature of the evaporator with a simple system configuration at a low cost.

In addition, even if a power failure occurs during operation of the compressor and power recovery is achieved before balancing between the inlet pressure and the outlet pressure of the compressor, the compressor can be immediately started up, thus quickly providing cooling even in a bad power supply condition in which power fails frequently.

A motor drive device according to an example of the exemplary embodiment of the present disclosure may be configured such that a pressure difference between an inlet and an outlet of a compressor is set to at least 0.05 MPa or more. This configuration can reduce a loss in a refrigeration cycle while reducing a progress of deterioration due to an increase in vibration of the motor drive device and maintaining reliability of the compressor.

A motor drive device according to an example of the exemplary embodiment of the present disclosure may be configured to drive a compressor in a refrigerator configured to provide a valve between the compressor and a condenser so as to close the valve at the time of stoppage of the compressor and open the valve at the time of driving the compressor. This configuration can further reduce a loss in a refrigeration cycle without further raising a temperature of an evaporator by preventing a high-temperature, the high-pressure refrigerant from returning from the condenser to the compressor.

Furthermore, a system can be formed with a simple configuration at a low cost as compared with a configuration using a four-way valve.

CLAIMS

1. A motor drive device comprising:

a brushless DC motor (5) configured to drive a load, the brushless DC motor (5) including a permanent magnet and a stator (5b) having a three-phase winding;

a speed controller (8) configured to decide a pulse width modulation (PWM) ON ratio for performing PWM control on the brushless DC motor (5);

a PWM ON ratio increasing-reducing unit (9) configured to increase or reduce the PWM ON ratio in accordance with a driving speed of the brushless DC motor (5); and

a drive unit (10) configured to perform the PWM control to drive the brushless DC motor (5) in accordance with the PWM ON ratio decided by the PWM ON ratio increasing-reducing unit (9),

a position detector (6) configured to detect a rotational position of the rotor (5a) based on a induced voltage generated in the three-phase winding of stator (5b); and

a speed detector (7) configured to calculate a current driving speed of the brushless DC motor (5) and an average speed of one past rotation from position information detected by the position detector (6), characterized in that

the PWM ON ratio increasing-reducing unit (9) sets the PWM ON ratio to a ratio equal to or lower than the PWM ON ratio decided by the speed controller (8) in an interval in which the driving speed of the brushless DC motor (5) is lower than a predetermined speed, and sets the PWM ON ratio to a ratio equal to or higher than the PWM ON ratio decided by the speed controller in an interval in which the driving speed is higher than the predetermined speed, , wherein the predetermined speed is the average speed

of one past rotation.

2. A refrigerator comprising the motor drive device according to claim 1,

wherein the motor drive device (30) drives a compressor (17,101) in a refrigeration cycle formed by sequentially connecting the compressor (17,101), a condenser (19, 102), a decompressor (20), an evaporator (21, 105), and the compressor (17, 101), and starts up while a pressure difference is left between an inlet side and an outlet side of the compressor.

3. The refrigerator according to claim 2, wherein the pressure difference is set to not less than 0.05 MPa.

4. The refrigerator (22) according to claim 2 or 3, further comprising a valve (18) provided between the compressor (17, 101) and the condenser (19, 102),

wherein the valve (18) is closed when the compressor (17, 101) is stopped and is opened when the compressor (17, 101) is operated.

5. The motor drive device according to claim 1, wherein

the position detector is further configured to detect a zero-cross point by comparing the induced voltage and a reference voltage for the zero-cross point of the induced voltage, and the speed detector is further configured to detect a zero-cross point detection interval, which is an interval between the zero-cross point and a next zero-cross point of a plurality of zero-cross points detected during the one past rotation, so as to calculate the average speed of the one past rotation from a sum of the zero-cross point detection interval.

6. The motor drive device according to claim 5, wherein

an interval in which a current value of the zero-cross point detection interval is lower than an average of a plurality of the zero-cross point detection interval of the one past rotation corresponds to the interval in which the driving speed of the brushless DC motor is lower than the predetermined speed, and an interval in which the current value of the zero-cross point detection interval is smaller than the average of the plurality of the zero-cross point detection interval of the one past rotation corresponds to the interval in which the driving speed of the brushless DC motor is higher than the predetermined speed.